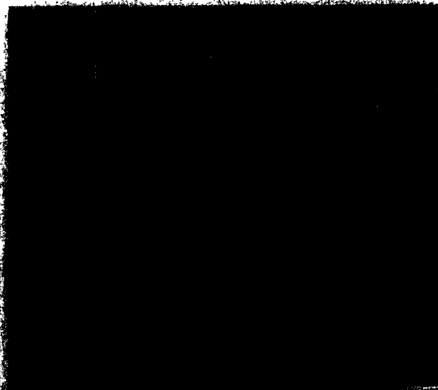
CARBON FIBER INSTALLATION AT INTERMOUNTAIN POWER SERVICE CORPORATION
UNIT 1 - MARCH [illegible]
84", 114" & 120" Diameter PCCP Pipe Sections



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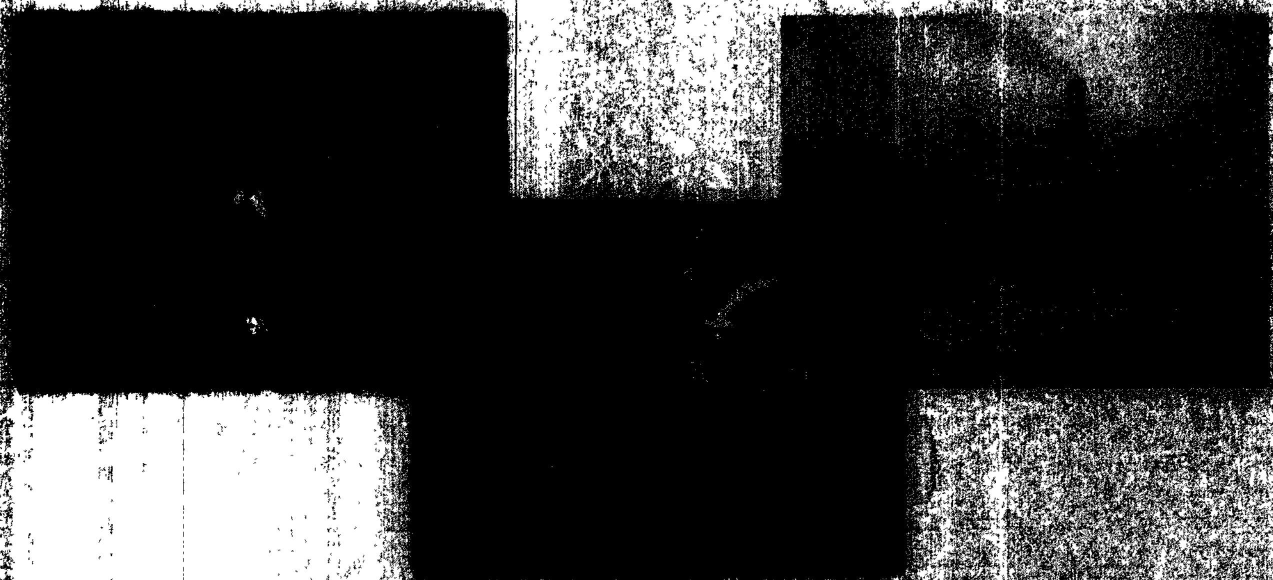

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CARBON FIBER INSTALLATION REPORT

FOR

INTERMOUNTAIN POWER GENERATION STATION

COOLING WATER SYSTEM – UNIT 1

MARCH 6TH THRU 23RD OF 2005

PREPARED FOR

INTERMOUNTAIN POWER SERVICE CORPORATION

INTERMOUNTAIN POWER GENERATION STATION

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REPORT FOR WORK COMPLETED ON PCCP FOR UNIT 1

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1. INTRODUCTION

In March of 2005, carbon fiber was installed in thirty-seven (37) PCCP pipes in the return line and one (1) PCCP pipe in the supply line for Unit 1 at Intermountain Power Generation Station. The carbon fiber installation had four stages: preparation of the pipe, the fiber installation, the Cabosil application, and the Abrasive Resistive Coating application. This report summarizes tasks in these stages that were completed for each of the pipes, and the report includes [redacted] or items that were noticed while repairing the pipes.

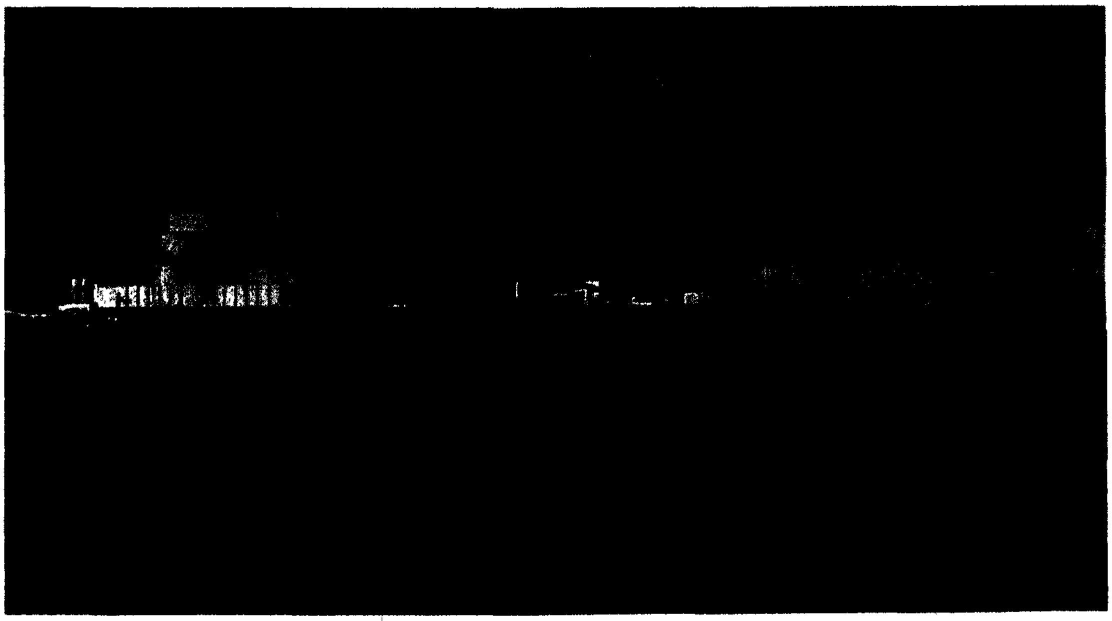


Figure 1: Intermountain Power Generation Station

2. Repair of Pipe Spools

2.1. Access Manhole No. 2B

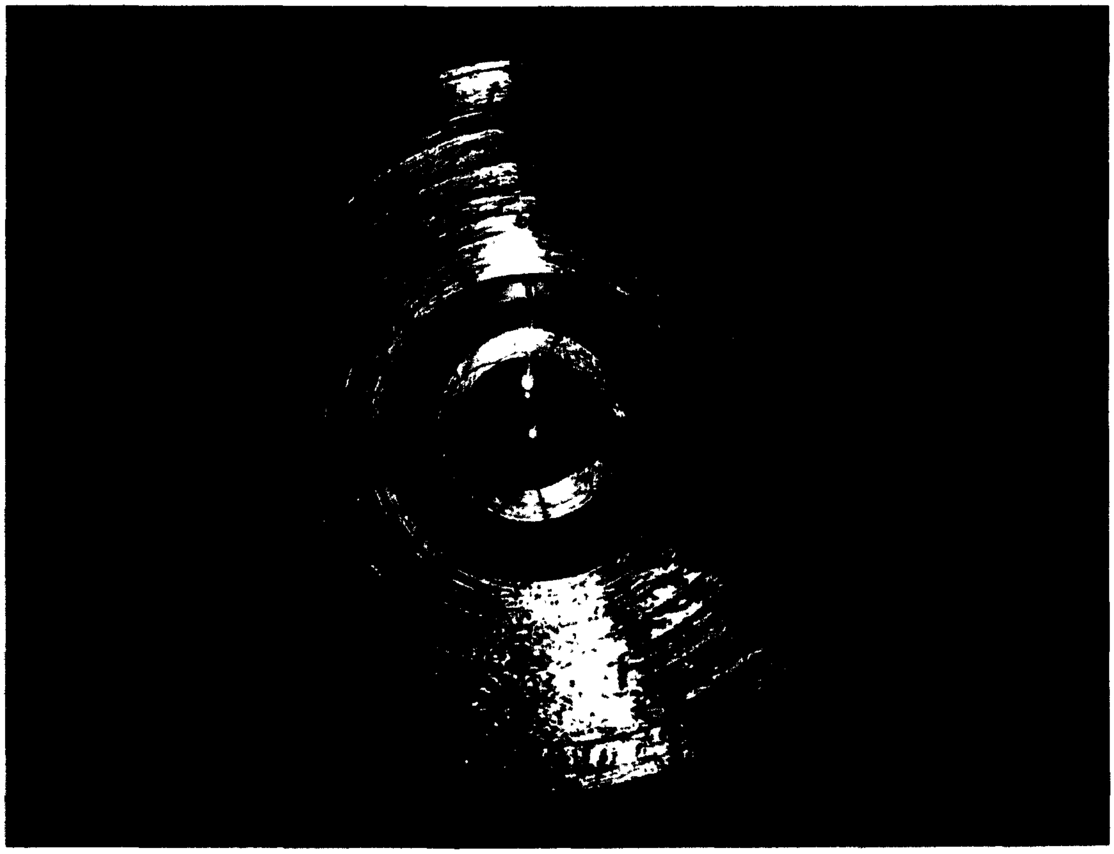


Figure 2: Spool 480 and 533 Looking Toward Manhole 2B

2.1.1. Pipe Spool No. 428

Pipe size	=	84 inches
Pipe length	=	20 feet

On March 7th, 2005, there were several tasks that were performed in order to prepare the spool for the carbon fiber application. During the night shift, the roughness of the sand blasted, concrete surface was verified at ±1/16" amplitude. During the day shift, excess water and debris were removed, the spool was crack mapped, and the cracks were established to be clean. While crack mapping, there were several hoop cracks that were found in the pipe (See Appendix A).

On March 8th, 2005, there were a few items that were finalized for the preparation of the spool, and several tasks were completed for the installation of the carbon fiber on the spool. The cracks were sealed with Injection Resin PRI 2000-1-J-A & B, and the prime coating of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was applied. Before the application of the prime coat, the mixture was confirmed to be 4 parts of the resin to 1 part of the hardener. One hour after the prime coating, the epoxy bonding agent was applied to the concrete surface, and the first layer of carbon fiber was completed. During the installation, the overlaps of the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction, and the wrap orientation and alignment with the pipe axis were established. While the fiber was being placed, bubbles and wrinkles that could be seen were fixed. After each hoop of fiber was laid, the edges were tapered and sealed with a thin layer of epoxy bonding agent. During the application, the saturation mixture of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was verified at 4 to 1, respectively, and the saturation of the carbon fiber was observed to be at 1 quart per 4 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked.

On March 9th, 2005, the installation of the carbon fiber was finished. The second layer of carbon fiber was applied per the contract documents. While the fiber was placed, the overlaps of the fabric were confirmed to be 9" in the hoop direction and 2" in the longitudinal direction. Also, the alignment of the fiber was checked to be per contract documents. Any bubbles or wrinkles that were seen were worked out of the fiber. During the installation, the saturation mixture of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was verified at 4 to 1, respectively, and the saturation of the carbon fiber was changed and observed to be 1 quart per 3 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was inspected.

On March 10th, 2005, the final coating of the epoxy bonding agent was started on the top half of the pipe. During the application, the proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was confirmed.

On March 11th, 2005, the top half of the pipe was checked for voids, and the voids were injected using Injection Resin PRI 2000-1-J-A & B.

On March 18th, 2005, during the night shift, the epoxy bonding agent was placed on the carbon fiber edges on the bottom, seams on the bottom, and at the joints. During the application, the proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was inspected. During the day shift, the final layer of epoxy bonding agent was sprayed across the entire spool. [redacted] Rolsb

On March 19th, 2005, the bottom half of the pipe was checked for voids, and these voids were filled using PRI 2000-1-J-A & B. Also, ridges, lines, and splatters in the epoxy bonding agent were grinded until smooth.

On March 20th, 2005, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and observed to be at a 3 to 1 ratio, respectively. Then, the first coat of the ARC was applied to the spool.

On March 21st, 2005, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and confirmed at a 3 to 1 ratio, respectively. Then, the second coat of the ARC was rolled on to the spool.

On March 22nd, 2005, the final inspection was performed on the pipe.

2.1.2. Pipe Spool No. 535

Pipe size	=	84 inches
Pipe length	=	12 feet

On March 7th, 2005, there were several tasks that were performed in order to prepare the spool for the carbon fiber installation. During the night shift, the roughness of the sand blasted, concrete surface was verified at ±1/16" amplitude. During the day shift, excess water and debris were removed, the spool was crack mapped, and the cracks were confirmed to be clean. While crack mapping, there were several hoop cracks, a spiral crack that needed a patch, and two longitudinal cracks that needed patches that were found in the pipe (See Appendix A).

On March 9th, 2005, there were a few items that were finalized for the preparation of the spool. The cracks were sealed with Injection Resin PRI 2000-1-J-A & B, and the prime coating of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was applied. Before the application of the prime coat, the mixture was observed to be 4 parts of the resin to 1 part of the hardener.

On March 10th, 2005, the application of the carbon fiber on the spool was completed, and the final coat of epoxy bonding agent was started. First, the epoxy bonding agent was applied to the concrete surface, and two 5'-0", one 7'-4", one 9'-6", and one 15'-7" crack patch were applied for the cracks mentioned above. After the patches were applied, the first layer of carbon fiber was applied. During the installation, the overlaps of the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction, and the wrap orientation and alignment with the pipe axis were checked. While the fiber was being installed, any bubbles and wrinkles that could be seen were worked out of the fiber. After each hoop of fiber was installed, the edges were tapered and sealed with a thin layer of epoxy bonding agent. Then, the second layer of carbon fiber was laid per the contract documents. While the fiber was applied, the overlaps of the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction. Also, the alignment of the fiber was checked to be per contract documents. Any bubbles or wrinkles that were seen were repaired. During the installation, the saturation mixture of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was inspected and found to be at 4 to 1, respectively, and the saturation of the carbon fiber was established at 1 quart per 3 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked. Once the fiber was installed, the final coating of the epoxy bonding agent was started on the top half of the pipe. During the application, the proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked.

On March 11th, 2005, the top half of the pipe was checked for voids, and the voids were injected using Injection Resin PRI 2000-1-J-A & B.

On March 18th, 2005, during the night shift, the epoxy bonding agent was applied to the carbon fiber edges on the bottom, seams on the bottom, and at the joints. During the application, the proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was confirmed. During the day shift, the final layer of epoxy bonding agent was sprayed across the entire spool.

On March 19th, 2005, the bottom half of the pipe was checked for voids, and these voids were injected using PRI 2000-1-J-A & B. While checking for voids, the spool and [redacted]w. Also, ridges, lines, and splatters in the epoxy bonding agent were grinded until smooth.

On March 20th, 2005, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and inspected for a 3 to 1 ratio, respectively. Then, the first coat of the ARC was applied to the spool.

On March 21st, 2005, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and observed to be at a 3 to 1 ratio, respectively. Then, the second coat of the ARC was applied to the spool.

On March 22nd, 2005, the final inspection was performed on the pipe.

2.1.3. Pipe Spool No. 533

Pipe size = 84 inches

Pipe length = 20 feet

On March 7th, 2005, there were several tasks that were performed in order to prepare the spool for the carbon fiber installation. During the night shift, the roughness of the sand blasted, concrete surface was inspected and found to be at ±1/16" amplitude. During the day shift, excess water and debris were removed, the spool was crack mapped, and the cracks were cleaned. While crack mapping, there were several hoop cracks, a spiral crack, and a longitudinal crack that needed a patch that were found in the pipe (See Appendix A).

On March 9th, 2005, the cracks were sealed with Injection Resin PRI 2000-1-J-A & B.

On March 10th, 2005, the prime coating of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was applied. Before the application of the prime coat, the mixture was observed to be at 4 parts of the resin to 1 part of the hardener.

On March 13th, 2005, the application of the carbon fiber on the spool was completed. First, the epoxy bonding agent was applied to the concrete surface, and one 8'-0" crack patch was laid for the crack mentioned above. After the patch was installed, the first layer of carbon fiber was applied. During the installation, the overlaps of the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction, and the wrap orientation and alignment with the pipe axis were checked. While the fiber was being installed, any bubbles and wrinkles that could be seen were repaired. After each hoop of fiber was installed, the edges were tapered and sealed with a thin layer of epoxy bonding agent. Then, the second layer of carbon fiber was applied per the contract documents. While the fiber was laid the overlaps of the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction. Also, the alignment of the fiber was checked to be per contract documents. Any bubbles or wrinkles that were seen were worked out of the fiber. During the installation, the saturation mixture of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was checked for a 4 to 1 ratio, respectively, and the saturation of the carbon fiber was established at 1 quart per 3 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked.

On March 18th, 2005, during the night shift, the epoxy bonding agent was applied to the carbon fiber, seams on the bottom, and at the joints. During the application, the proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was reviewed. During the day shift, the final layer of epoxy bonding agent was sprayed across the entire spool.

On March 19th, 2005, the pipe was checked for voids, and these voids were injected using PRI 2000-1-J-A & B. Also, ridges, lines, and splatters in the epoxy bonding agent were grinded until smooth.

On March 20th, 2005, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and inspected and found to be at a 3 to 1 ratio, respectively. Then, the first coat of the ARC was applied to the spool.

On March 21st, 2005, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and checked at a 3 to 1 ratio, respectively. Then, the second coat of the ARC was applied to the spool.

On March 22nd, 2005, the final inspection was performed on the pipe.

2.1.4. Pipe Spool No. 480

Pipe size = 84 inches

Pipe length = 16 feet

On March 7th, 2005, there were several tasks that were performed in order to prepare the spool for the carbon fiber installation. During the night shift, the roughness of the sand blasted, concrete surface was established at ±1/16" amplitude. During the day shift, excess water and debris were removed, the spool was crack mapped, and the cracks were observed to be clean. While crack mapping, there were several hoop cracks that were found in the pipe (See Appendix A).

On March 9th, 2005, the cracks were sealed with Injection Resin PRI 2000-1-J-A & B.

On March 10th, 2005, the prime coating of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was applied. Before the application of the prime coat, the mixture was confirmed to be at 4 parts of the resin to 1 part of the hardener.

On March 13th, 2005, the installation of the carbon fiber on the spool was completed. First, the epoxy bonding agent was applied to the concrete surface. Then, the first layer of carbon fiber was installed. During the installation, the overlaps of the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction, and the wrap orientation and alignment with the pipe axis were checked. While the fiber was being applied, any bubbles and wrinkles that could be seen were fixed. After each hoop of fiber was laid, the edges were tapered and sealed with a thin layer of epoxy bonding agent. Then, the second layer of carbon fiber was installed per the contract documents.

While the fiber was applied, the overlaps of the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction. Also, the alignment of the fiber was checked to be per contract documents. Any bubbles or wrinkles that were seen were repaired. During the installation, the saturation mixture of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was verified at 4 to 1, respectively, and the saturation of the carbon fiber was verified at 1 quart per 3 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked.

On March 18th, 2005, during the night shift, the epoxy bonding agent was applied to the carbon fiber edges, seams on the bottom, and at the joints. During the application, the proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was inspected. During the day shift, the final layer of epoxy bonding agent was sprayed across the entire spool.

On March 19th, 2005, the pipe was checked for voids, and these voids were injected using PRI 2000-1-J-A & B. Also, ridges, lines, and splatters in the epoxy bonding agent were grinded until smooth.

On March 20th, 2005, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and confirmed to be at a 3 to 1 ratio, respectively. Then, the first coat of the ARC was applied to the spool.

On March 21st, 2005, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and observed at a 3 to 1 ratio, respectively. Then, the second coat of the ARC was applied to the spool.

On March 22nd, 2005, the final inspection was performed on the pipe.

2.1.5. Pipe Spool No. 430

Pipe size = 84 inches

Pipe length = 19.98 feet

On March 7th, 2005, there were several tasks that were performed in order to prepare the spool for the carbon fiber installation. During the night shift, the roughness of the sand blasted, concrete surface was verified at ±1/16" amplitude. During the day shift, excess water and debris were removed, the spool was crack mapped, and the cracks were established to be clean. While crack mapping, there were several hoop cracks that were found in the pipe (See Appendix A).

On March 9th, 2005, the cracks were sealed with Injection Resin PRI 2000-1-J-A & B.

On March 10th, 2005, the prime coating of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was applied. Before the application of the prime coat, the mixture was reviewed and found to be at 4 parts of the resin to 1 part of the hardener.

On March 11th, 2005, the installation of the carbon fiber on the spool was started. First, the epoxy bonding agent was applied to the concrete surface. Then, the first layer of carbon fiber was installed. During the installation, the overlaps of the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction, and the wrap orientation and alignment with the pipe axis were checked. While the fiber was being laid, any bubbles and wrinkles that could be seen were repaired. After each hoop of fiber was applied, the edges were tapered and sealed with a thin layer of epoxy bonding agent. During the installation, the saturation mixture of Saturating Resin PRI 2000-3-R-A &

2000-5-HR-B was verified at 4 to 1, respectively, and the saturation of the carbon fiber was observed to be at 1 quart per 3 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked.

On March 12th, 2005, the carbon fiber installation was completed. First, the second layer of carbon fiber was installed per the contract documents. While the fiber was installed, the overlaps of the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction. Also, the alignment of the fiber was checked to be per contract documents. Any bubbles or wrinkles that were seen were worked out of the fiber. During the installation, the saturation mixture of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was verified at 4 to 1, respectively, and the saturation of the carbon fiber was inspected and found to be at 1 quart per 3 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked.

On March 18th, 2005, during the night shift, the epoxy bonding agent was applied to the carbon fiber edges, seams on the bottom, and at the joints. During the application, the proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was observed. During the day shift, the final layer of epoxy bonding agent was sprayed across the entire spool.

On March 19th, 2005, the pipe was checked for voids, and these voids were injected using PRI 2000-1-J-A & B. While checking for voids, the spool was found to sound hollow, but could not be injected; therefore, the hollow sound was in the pipe not in the fiber. Also, ridges, lines, and splatters in the epoxy bonding agent were grinded until smooth.

On March 20th, 2005, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and verified at a 3 to 1 ratio, respectively. Then, the first coat of the ARC was applied to the spool.

On March 21st, 2005, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and confirmed to be at a 3 to 1 ratio, respectively. Then, the second coat of the ARC was applied to the spool.

On March 22nd, 2005, the final inspection was performed on the pipe.

2.1.6. Pipe Spool No. 532A

Pipe size = 84 inches

Pipe length = 19.90 feet

On March 7th, 2005, there were several tasks that were performed in order to prepare the spool for the carbon fiber installation. During the night shift, the roughness of the sand blasted, concrete surface was verified at ±1/16" amplitude. During the day shift, excess water and debris were removed, the spool was crack mapped, and the cracks were observed to be clean. While crack mapping, there were several hoop cracks that were found in the pipe (See Appendix A).

On March 9th, 2005, the cracks were sealed with Injection Resin PRI 2000-1-J-A & B.

On March 10th, 2005, the prime coating of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was applied. Before the application of the prime coat, the mixture was confirmed to be at 4 parts of the resin to 1 part of the hardener.

On March 11th, 2005, the installation of the carbon fiber on the spool was started. First, the epoxy bonding agent was applied to the concrete surface. Then, the first layer of carbon fiber was installed. During the installation, the overlaps of the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction, and the wrap orientation and alignment with the pipe axis were checked. While the fiber was being applied, any bubbles and wrinkles that could be seen were fixed. After each hoop of fiber was laid, the edges were tapered and sealed with a thin layer of epoxy bonding agent. During the installation, the saturation mixture of Saturating Resin PRI 2000-3-R-A &

2000-5-HR-B was observed to be at a 4 to 1, respectively, and the saturation of the carbon fiber was verified at 1 quart per 3 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked.

On March 12th, 2005, the carbon fiber installation was completed. First, the second layer of carbon fiber was installed per the contract documents. While the fiber was installed, the overlaps of the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction. Also, the alignment of the fiber was checked to be per contract documents. Any bubbles or wrinkles that were seen were repaired. During the installation, the saturation mixture of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was found to be at a 4 to 1, respectively, and the saturation of the carbon fiber was verified at 1 quart per 3 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked.

On March 18th, 2005, during the night shift, the epoxy bonding agent was applied to the carbon fiber edges, seams on the bottom, and at the joints. During the application, the proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was observed. During the day shift, the final layer of epoxy bonding agent was sprayed across the entire spool.

On March 19th, 2005, the pipe was checked for voids, and these voids were injected using PRI 2000-1-J-A & B. Also, ridges, lines, and splatters in the epoxy bonding agent were grinded until smooth.

On March 20th, 2005, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and observed at a 3 to 1 ratio, respectively. Then, the first coat of the ARC was applied to the spool.

On March 21st, 2005, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and verified at a 3 to 1 ratio, respectively. Then, the second coat of the ARC was applied to the spool.

On March 22nd, 2005, the final inspection was performed on the pipe.

2.1.7. Pipe Spool No. 339

Pipe size = 84 inches

Pipe length = 20 feet

On March 7th, 2005, there were several tasks that were performed in order to prepare the spool for the carbon fiber application. During the night shift, the roughness of the sand blasted, concrete surface was established at ±1/16" amplitude. During the day shift, excess water and debris were removed, the spool was crack mapped, and the cracks were inspected to be clean. While crack mapping, there were several hoop cracks that were found in the pipe (See Appendix A).

On March 9th, 2005, the cracks were sealed with Injection Resin PRI 2000-1-J-A & B.

On March 10th, 2005, the prime coating of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was applied. Before the application of the prime coat, the mixture was confirmed at 4 parts of the resin to 1 part of the hardener.

On March 11th, 2005, the installation of the carbon fiber on the spool was started. First, the epoxy bonding agent was applied to the concrete surface. Then, the first layer of carbon fiber was applied. During the installation, the overlaps of the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction, and the wrap orientation and alignment with the pipe axis were checked. While the fiber was being laid, any bubbles and wrinkles that could be seen were worked out of the fiber. After each hoop of fiber was installed, the edges were tapered and sealed with a thin layer of epoxy bonding agent. During the installation, the saturation mixture of Saturating Resin

PRI 2000-3-R-A & 2000-5-HR-B was verified at 4 to 1, respectively, and the saturation of the carbon fiber was observed and found to be at 1 quart per 3 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked.

On March 12th, 2005, the carbon fiber installation was completed. First, the second layer of carbon fiber was installed per the contract documents. While the fiber was installed, the overlaps of the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction. Also, the alignment of the fiber was checked to be per contract documents. Any bubbles or wrinkles that were seen were repaired. During the installation, the saturation mixture of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was found to be at a 4 to 1, respectively, and the saturation of the carbon fiber was verified at 1 quart per 3 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked.

On March 18th, 2005, during the night shift, the epoxy bonding agent was applied to the carbon fiber edges, seams on the bottom, and at the joints. During the application, the proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked. During the day shift, the final layer of epoxy bonding agent was sprayed across the entire spool.

On March 19th, 2005, the pipe was checked for voids, and these voids were injected using PRI 2000-1-J-A & B. While checking for voids, the spool was found to sound hollow, but could not be injected; therefore, the hollow sound was in the pipe not in the fiber. .Also, ridges, lines, and splatters in the epoxy bonding agent were grinded until smooth.

On March 20th, 2005, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and verified at a 3 to 1 ratio, respectively. Then, the first coat of the ARC was applied to the spool.

On March 21st, 2005, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and confirmed to be at a 3 to 1 ratio, respectively. Then, the second coat of the ARC was applied to the spool.

On March 22nd, 2005, the final inspection was performed on the pipe.

2.2. Access Manhole No. 2A

Figure 3: Spool 516 and 505 Looking Toward manhole 2A

2.2.1. Pipe Spool No. 516

Pipe size	=	120 inches
Pipe length	=	16 feet

On March 8th, 2005, there were several tasks that were performed to prepare the pipe for the carbon fiber installation. During the night shift, the roughness of the sand blasted, concrete surface was confirmed to be ±1/16" amplitude. During the day shift, the spool was crack mapped, and the excess water and debris were removed. While crack mapping, there were several hoop cracks that were found in the pipe (See Appendix A).

On March 9th, 2005, there were several tasks that were accomplished to prepare the pipe for the carbon fiber installation. During the day shift, the cracks were verified to be clean. During the night shift, the cracks were sealed with Injection Resin PRI 2000-1-J-A & B.

On March 10th, 2005, there were a few items that were finalized for the preparation of the spool, and several tasks were performed for the installation of the carbon fiber on the spool. First, the prime coating of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was applied. Before the application of the prime coat, the mixture was inspected and found to be 4 parts of the resin to 1 part of the hardener. One hour after the prime coating, the epoxy bonding agent was applied to the concrete surface, and the spring lines were applied. Then, the first layer of carbon fiber was installed. During the installation, the overlaps of the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction, and the wrap orientation and alignment with the pipe axis were checked. While the fiber was being installed, any bubbles and wrinkles that could be seen were worked out of the fiber. During the installation, the saturation mixture of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was observed at 4 to 1, respectively, and the saturation of the carbon fiber was verified at 1 quart per 3 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked.

On March 11th, 2005, the installation of the carbon fiber was completed. First, the second layer of carbon fiber and the termination hoops were laid. While the fiber was installed, the overlaps the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction. Also, the alignment of the fiber was checked to be per contract documents. Any bubbles or wrinkles that were seen were fixed. During the installation, the saturation mixture of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was confirmed to be 4 to 1, respectively, and the saturation of the carbon fiber was inspected and found to be at 1 quart per 3 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked.

On March 19th, 2005, during the night shift, the final coating of the epoxy bonding agent was sprayed on the entire pipe. During the application, the proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was verified. There was a small area of [redacted] while the spray was applied. This area will need to be grinded until the ridges are smooth.

On March 20th, 2005, the pipe was checked for voids, and the voids were injected using Injection Resin PRI 2000-1-J-A & B. Also, any ridges, lines, or splatters of Cabosil were grinded until smooth.

On March 21st, 2005, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and observed at a 3 to 1 ratio, respectively. Then, the first coat of the ARC was applied to the spool.

On March 22nd, 2005, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and found to be a 3 to 1 ratio, respectively. Then, the second coat of the ARC was applied to the spool.

On March 23rd, 2005, the final inspection was performed on the pipe.

2.2.2. Pipe Spool No. 505

Pipe size = 120 inches

Pipe length = 16 feet

On March 8th, 2005, there were several tasks that were accomplished to prepare the pipe for the carbon fiber installation. During the night shift, the roughness of the sand blasted, concrete surface was verified at ±1/16" amplitude. During the day shift, the spool was crack mapped, and the cracks were inspected and found to be clean. While crack mapping, there were several hoop cracks that were found in the pipe (See Appendix A).

On March 9th, 2005, there were several tasks that were performed to prepare the pipe for the carbon fiber installation. During the day shift, excess water and debris were removed. During the night shift, the cracks were sealed with Injection Resin PRI 2000-1-J-A & B.

On March 13th, 2005, there were a few items that were finalized for the preparation of the spool, and several tasks were accomplished for the installation of the carbon fiber on the spool. First, the prime coating of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was applied. Before the application of the prime coat, the mixture was confirmed to be at 4 parts of the resin to 1 part of the hardener. One hour after the prime coating, the epoxy bonding agent was applied to the concrete surface, and the spring lines were laid. Then, the first layer of carbon fiber was applied. During the installation, the overlaps of the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction, and the wrap orientation and alignment with the pipe axis were checked. While the fiber was being installed, any bubbles and wrinkles that could be seen were fixed. During the installation, the saturation mixture of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was observed to be 4 to 1, respectively, and the saturation of the carbon fiber was verified at 1 quart per 3 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked.

On March 14th, 2005, the installation of the carbon fiber was completed. First, the second layer of carbon fiber and the termination hoops were installed. While the fiber was laid, the overlaps the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction. Also, the alignment of the fiber was checked to be per contract documents. Any bubbles or wrinkles that were seen were repaired. During the installation, the saturation mixture of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was found to be 4 to 1, respectively, and the saturation of the carbon fiber was observed to be 1 quart per 3 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked.

On March 19th, 2005, during the night shift, the final coating of the epoxy bonding agent was sprayed on the entire pipe. During the application, the proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was inspected.

On March 20th, 2005, the pipe was checked for voids, and the voids were injected using Injection Resin PRI 2000-1-J-A & B. During this time, the ridges, lines, and splatters in the Cabosil were grinded until smooth.

On March 21st, 2005, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and verified at a 3 to 1 ratio, respectively. Then, the first coat of the ARC was applied to the spool.

On March 22nd, 2005, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and observed at a 3 to 1 ratio, respectively. Then, the second coat of the ARC was applied to the spool.

On March 23rd, 2005, the final inspection was performed on the pipe.

2.2.3. Pipe Spool No. 408

Pipe size = 120 inches

Pipe length = 16 feet

On March 8th, 2005, there were several tasks that were completed to prepare the pipe for the for the carbon fiber installation. During the night shift, the roughness of the sand blasted, concrete surface was verified at ±1/16" amplitude. During the day, the spool was crack mapped, and the cracks were found to be clean. While crack mapping, there were several hoop cracks that were found in the pipe (See Appendix A).

On March 9th, 2005, there were several tasks that were performed to prepare the pipe for the carbon fiber installation. During the day shift, excess water and debris were removed. During the night shift, the cracks were sealed with Injection Resin PRI 2000-1-J-A & B.

On March 10th, 2005, there were a few items that were finalized for the preparation of the spool, and several tasks were performed for the installation of the carbon fiber on the spool. First, the prime coating of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was applied. Before the application of the prime coat, the mixture was observed to be at 4 parts of the resin to 1 part of the hardener. One hour after the prime coating, the epoxy bonding agent was applied to the concrete surface, and the spring lines were placed along with the first hoop of the first layer of carbon fiber.. During the installation, the overlaps of the fabric were checked at 9" in the hoop direction, and the wrap orientation and alignment with the pipe axis were checked. While the fiber was being installed, any bubbles and wrinkles that could be seen were worked out of the fiber.

 [redacted]

No mention of 2:1 ratio 1qt/3LF

On March 12th, 2005, the installation of the carbon fiber was completed. First, seven hoops of the first layer of carbon fiber were placed. During the installation, the overlaps of the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction, and the wrap orientation and alignment with the pipe axis were checked. After each hoop of fiber was laid, the edges were tapered and sealed with a thin layer of epoxy bonding agent. Then, the second layer of carbon fiber and the termination hoops were installed. While the fiber was applied, the overlaps the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction. Also, the alignment of the fiber was checked to be per contract documents. Any bubbles or wrinkles that were seen were repaired. During the installation, the saturation mixture of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was verified at 4 to 1, respectively, and the saturation of the carbon fiber was also verified at 1 quart per 3 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked.

On March 19th, 2005, during the night shift, the final coating of the epoxy bonding agent was sprayed on the entire pipe. During the application, the proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was confirmed.

On March 20th, 2005, the pipe was checked for voids, and the voids were injected using Injection Resin PRI 2000-1-J-A & B. Also, lines, ridges, splatters on the Cabosil were grinded until smooth.

On March 21st, 2005, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and inspected and found to be at a 3 to 1 ratio, respectively. Then, the first coat of the ARC was applied to the spool.

On March 22nd, 2005, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and verified at a 3 to 1 ratio, respectively. Then, the second coat of the ARC was applied to the spool.

On March 23rd, 2005, the final inspection was performed on the pipe.

2.2.4. Pipe Spool No. 319

Pipe size = 120 inches

Pipe length = 16 feet

On March 8th, 2005, there were several tasks that were performed to prepare the pipe for the carbon fiber installation. First, the roughness of the sand blasted, concrete surface was verified at ±1/16" amplitude. During the day shift, excess water and debris were removed, the spool was crack mapped, and the cracks were observed to be clean. While crack mapping, there were several hoop cracks that were found in the pipe, and one of these hoops required a patch (See Appendix A).

On March 9th, 2005, the cracks were sealed with Injection Resin PRI 2000-1-J-A & B.

On March 14th, 2005, there were a few items that were finalized for the preparation of the spool. First, the prime coating of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was applied. Before the application of the prime coat, the mixture was verified at 4 parts of the resin to 1 part of the hardener.

On March 15th, 2005, the carbon fiber installation was started. First, the epoxy bonding agent was applied to the concrete surface. Next, the spring lines and the 32'-9" crack patch for the crack mentioned above were applied. Then, the first layer of carbon fiber was installed. During the installation, the overlaps of the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction, and the wrap orientation and alignment with the pipe axis were checked. While the fiber was being laid, any bubbles and wrinkles that could be seen were repaired. During the installation, the saturation mixture of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was observed at 4 to 1, respectively, and the saturation of the carbon fiber was inspected and found to be at 1 quart per 3 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked.

On March 16th, 2005, the installation of the carbon fiber was completed. First, the second layer of carbon fiber and the termination hoops were installed. While the fiber was applied, the overlaps the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction. Also, the alignment of the fiber was checked to be per contract documents. Any bubbles or wrinkles that were seen were worked out of the fiber. During the installation, the saturation mixture of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was verified at 4 to 1, respectively, and the saturation of the carbon fiber was confirmed at 1 quart per 3 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked.

On March 18th, 2005, several tasks were accomplished to prepare the pipe for the final coat of epoxy bonding agent. First, the proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was inspected. Then, the epoxy bonding agent was applied to the edges of the fiber and joints.

On March 19th, 2005, during the night shift, the final coating of the epoxy bonding agent was sprayed on the entire pipe. During the application, the proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was verified.

On March 21st, 2005, the pipe was checked for voids, and the voids were injected using Injection Resin PRI 2000-1-J-A & B. At this time, any ridges, lines, or splatters on the Cabosil were grinded until smooth.

On March 22nd, 2005, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and verified at a 3 to 1 ratio, respectively. Then, the first coat of the ARC was applied to the spool. Approximately four to six hours later, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and confirmed at a 3 to 1 ratio, respectively. Then, the second coat of the ARC was applied to the spool.

On March 23rd, 2005, the final inspection was performed on the pipe.

2.2.5. Pipe Spool No. 499

Pipe size = 120 inches

Pipe length = 16 feet

On March 8th, 2005, there were several tasks that were performed to prepare the pipe for the carbon fiber installation. First, the roughness of the sand blasted, concrete surface was checked to be at ±1/16" amplitude. During the day shift, excess water and debris were removed, the spool was crack mapped, and the cracks were verified to be clean. While crack mapping, there were several hoop cracks and two longitudinal cracks which required patches that were found in the pipe (See Appendix A).

On March 9th, 2005, there were a few items that were finalized for the preparation of the spool. First, the cracks were sealed with Injection Resin PRI 2000-1-J-A & B. Then, the prime coating of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was applied. Before the application of the prime coat, the mixture was verified at 4 parts of the resin to 1 part of the hardener.

On March 13th, 2005, the carbon fiber installation was started. First, the epoxy bonding agent was applied to the concrete surface. Next, the spring lines, a 11'-0" patch, and a 5'-4" patch for the cracks listed above were installed. Then, the first layer of carbon fiber was applied. During the installation, the overlaps of the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction, and the wrap orientation and alignment with the pipe axis were checked. While the fiber was being installed, any bubbles and wrinkles that could be seen were fixed. During the installation, the saturation mixture of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was observed to be 4 to 1, respectively, and the saturation of the carbon fiber was verified at 1 quart per 3 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked.

On March 15th, 2005, two hoops of the second layer of carbon fiber were applied. While the fiber was laid, the overlaps the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction. Also, the alignment of the fiber was checked to be per contract documents. Any bubbles or wrinkles that were seen were repaired. During the installation, the saturation mixture of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was verified at 4 to 1, respectively, and the saturation of the carbon fiber was verified at 1 quart per 3 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked.

On March 16th, 2005, the carbon fiber installation was completed. First, the rest of the second layer of fiber and the termination hoops were installed. While the fiber was installed, the overlaps the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction. Also, the alignment of the fiber was checked to be per contract documents. Any bubbles or wrinkles that were seen were repaired. During the installation, the saturation mixture of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was verified at 4 to 1, respectively, and the saturation of the carbon fiber was verified at 1 quart per 3 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked.

On March 18th, 2005, several tasks were performed to prepare the pipe for the final coat of epoxy bonding agent. First, the proper mixing of epoxy bonding agent using

Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was inspected. Then, the epoxy bonding agent was applied to the edges of the fiber and joints.

On March 19th, 2005, during the night shift, the final coating of the epoxy bonding agent was sprayed on the entire pipe. During the application, the proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was observed.

On March 21st, 2005, the pipe was checked for voids, and the voids were injected using Injection Resin PRI 2000-1-J-A & B. Finally, any ridges, lines, or splatters were grinded until smooth.

On March 22nd, 2005, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and verified at a 3 to 1 ratio, respectively. Then, the first coat of the ARC was applied to the spool. Approximately four to six hours later, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and checked to be at 3 to 1 ratio, respectively. Then, the second coat of the ARC was applied to the spool.

On March 23rd, 2005, the final inspection was performed on the pipe.

2.2.6. Pipe Spool No. 496

Pipe size = 120 inches

Pipe length = 16 feet

On March 8th, 2005, there were several tasks that were accomplished to prepare the pipe for the carbon fiber installation. First, the roughness of the sand blasted, concrete surface was verified at ±1/16" amplitude. During the day shift, excess water and debris were removed, the spool was crack mapped, and the cracks were observed to be clean. While crack mapping, there were several hoop cracks were found in the pipe (See Appendix A).

On March 9th, 2005, there were a few items that were finalized for the preparation of the spool. First, the cracks were sealed with Injection Resin PRI 2000-1-J-A & B. Then, the prime coating of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was applied. Before the application of the prime coat, the mixture was confirmed at 4 parts of the resin to 1 part of the hardener.

On March 14th, 2005, the carbon fiber installation was started. First, the epoxy bonding agent was applied to the concrete surface, and the spring lines were laid. Then, the first layer of carbon fiber was applied. During the installation, the overlaps of the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction, and the wrap orientation and alignment with the pipe axis were checked. While the fiber was being applied, any bubbles or wrinkles that could be seen were fixed. During the installation, the saturation mixture of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was observed and found to be 4 to 1, respectively, and the saturation of the carbon fiber was verified at 1 quart per 3 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked.

On March 15th, 2005, the carbon fiber installation was almost completed. First, the second layer of fiber was installed. While the fiber was installed, the overlaps the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction. Also, the alignment of the fiber was checked to be per contract documents. Any bubbles or wrinkles that were seen were worked out of the fiber. During the installation, the saturation mixture of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was inspected and found to be 4 to 1, respectively, and the saturation of the carbon fiber was verified at 1 quart per 3 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked.

On March 16th, 2005, the carbon fiber installation was completed. First, termination hoops were laid. While the fiber was applied, the overlaps the fabric were checked at 9" in the hoop direction. Also, the alignment of the fiber was checked to be per contract documents. Any bubbles or wrinkles that were seen were repaired. During the installation, the saturation mixture of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was observed to be 4 to 1, respectively, and the saturation of the carbon fiber was verified at 1 quart per 3 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked.

On March 17th, 2005, several tasks were performed to prepare the pipe for the final coat of epoxy bonding agent. First, the proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was observed. Then, the epoxy bonding agent was applied to the edges of the fiber and joints.

On March 19th, 2005, during the night shift, the [redacted]. During the application, the proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was confirmed.

On March 21st, 2005, the pipe was [redacted] were injected using Injection Resin PRI 2000-1-J-A & B. Also, the ridges, lines, and splatters in the Cabosil were grinded until smooth.

On March 22nd, 2005, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and verified at a 3 to 1 ratio, respectively. Then, the [redacted]. Approximately four to six hours later, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and inspected and found to be at a 3 to 1 ratio, respectively. Then [redacted].

On March 23rd, 2005, the [redacted].

2.2.7. Pipe Spool No. 347A

Pipe size = 120 inches

Pipe length = 16 feet

On March 8th, 2005, there were several tasks that were accomplished to prepare the pipe for the carbon fiber installation. First, the roughness of the sand blasted, concrete surface was verified at ±1/16" amplitude. During the day shift, excess water and debris were removed, the spool was crack mapped, and the cracks were inspected to be clean. While crack mapping, there were several hoop cracks were found in the pipe (See Appendix A).

On March 9th, 2005, the cracks were sealed with Injection Resin PRI 2000-1-J-A & B.

On March 12th, 2005, there were a few items that were finalized to prepare the pipe for the carbon fiber installation. First, the prime coating of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was applied. Before the application of the prime coat, the mixture was confirmed at 4 parts of the resin to 1 part of the hardener.

On March 14th, 2005, the carbon fiber installation was started. First, the epoxy bonding agent was applied to the concrete surface, and the spring lines were installed. Then, the first layer of carbon fiber was applied. During the installation, the overlaps of the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction, and the wrap orientation and alignment with the pipe axis were checked. While the fiber was being installed, any bubbles or wrinkles that could be seen were repaired. During the installation, the saturation mixture of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was found to be at 4 to 1, respectively, and the saturation of the carbon fiber was verified at 1 quart per 3 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked.

On March 15th, 2005, the carbon fiber installation was completed. First, the second layer of fiber and the termination hoops were installed. While the fiber was laid, the overlaps the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction. Also, the alignment of the fiber was checked to be per contract documents. Any bubbles or wrinkles that were seen were fixed. During the installation, the saturation mixture of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was observed at 4 to 1, respectively, and the saturation of the carbon fiber was confirmed to be at 1 quart per 3 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked.using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked.

On March 17th and 18th, 2005, several tasks were performed to prepare the pipe for the final coat of epoxy bonding agent. First, the proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was verified. Then, the epoxy bonding agent was applied to the edges of the fiber and joints.

On March 19th, 2005, during the night shift, the final coating of the epoxy bonding agent was sprayed on the entire pipe. During the application, the proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was observed.

On March 21st, 2005, the pipe was checked for voids, and the voids were injected using Injection Resin PRI 2000-1-J-A & B. At this time, the ridges, lines, and splatters on the Cabosil were grinded until smooth.

On March 22nd, 2005, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and verified at a 3 to 1 ratio, respectively. Then, the first coat of the ARC was applied to the spool. Approximately four to six hours later, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and verified at a 3 to 1 ratio, respectively. Then, the second coat of the ARC was applied to the spool.

On March 23rd, 2005, the final inspection was performed on the pipe.

2.2.8. Pipe Spool No. 344A

Pipe size = 120 inches

Pipe length = 16 feet

On March 8th, 2005, during the night shift, the roughness of the sand blasted, concrete surface was confirmed to be ±1/16" amplitude.

On March 9th, 2005, , there were several tasks that were performed to prepare the pipe for the carbon fiber installation. First, excess water and debris were removed, the spool was crack mapped, and the cracks were verified to be clean. While crack mapping, there were several hoop cracks were found in the pipe (See Appendix A). Then, the cracks were sealed with Injection Resin PRI 2000-1-J-A & B.

On March 10th, 2005, there were a few items that were performed to prepare the pipe for the carbon fiber installation. First, the prime coating of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was applied. Before the application of the prime coat, the mixture was found to be at 4 parts of the resin to 1 part of the hardener.

On March 11th, 2005, the carbon fiber installation was started. First, the epoxy bonding agent was applied to the concrete surface, and the spring lines were installed. Then, the first layer of carbon fiber and 5 hoops of the second layer were applied. During the installation, the overlaps of the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction, and the wrap orientation and alignment with the pipe axis were checked. While the fiber was being applied, any bubbles or wrinkles that could be seen were worked out of the fiber. During the installation, the saturation mixture of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was observed at 4 to 1, respectively, and the saturation of the carbon fiber was inspected and found to be at 1 quart per 3 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked.

On March 12th, 2005, the carbon fiber installation was completed. First, six hoops of the second layer of fiber and the termination hoops were installed. While the fiber was installed, the overlaps the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction. Also, the alignment of the fiber was checked to be per contract documents. Any bubbles or wrinkles that were seen were repaired. During the installation, the saturation mixture of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was verified at 4 to 1, respectively, and the saturation of the carbon fiber was observed at 1 quart per 3 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked.using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked.

On March 17th and 18th, 2005, several tasks were accomplished to prepare the pipe for the final coat of epoxy bonding agent. First, the proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was inspected. Then, the epoxy bonding agent was applied to the edges of the fiber and joints.

On March 19th, 2005, the final coating of the epoxy bonding agent was sprayed on the entire pipe. During the application, the proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was observed.

On March 21st, 2005, the pipe was checked for voids, and the voids were injected using Injection Resin PRI 2000-1-J-A & B. During this time, the ridges, lines, and splatters in the Cabosil were grinded until smooth.

On March 22nd, 2005, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and verified at a 3 to 1 ratio, respectively. Then, the first coat of the ARC was applied to the spool. Approximately four to six hours later, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and confirmed at a 3 to 1 ratio, respectively. Then, the second coat of the ARC was applied to the spool.

On March 23rd, 2005, the final inspection was performed on the pipe.

2.2.9. Pipe Spool No. 343B

Pipe size = 120 inches

Pipe length = 16 feet

On March 8th, 2005, during the night shift, the roughness of the sand blasted, concrete surface was verified at ±1/16" amplitude.

On March 9th, 2005, there were several tasks that were performed to prepare the pipe for the carbon fiber installation. First, excess water and debris were removed, the spool was crack mapped, and the cracks were observed to be clean. While crack mapping, several hoop cracks were found in the pipe (See Appendix A). Then, the cracks were sealed with Injection Resin PRI 2000-1-J-A & B.

On March 10th, 2005, during the night shift, there were a few items that were performed to prepare the pipe for the carbon fiber installation. First, the prime coating of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was applied. Before the application of the prime coat, the mixture was confirmed at 4 parts of the resin to 1 part of the hardener.

On March 12th, 2005, the carbon fiber installation was started. First, the epoxy bonding agent was applied to the concrete surface, and the spring lines were applied. Then, the first layer of carbon fiber and 5 hoops of the second layer were applied. During the installation, the overlaps of the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction, and the wrap orientation and alignment with the pipe axis were checked. While the fiber was being installed, any bubbles or wrinkles that could be seen were fixed. During the installation, the saturation mixture of Saturating Resin PRI

2000-3-R-A & 2000-5-HR-B was inspected and found to be at 4 to 1, respectively, and the saturation of the carbon fiber was verified at 1 quart per 3 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked.

On March 13th, 2005, the carbon fiber installation was completed. First, six hoops of the second layer of fiber and the termination hoops were laid. While the fiber was applied, the overlaps the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction. Also, the alignment of the fiber was checked to be per contract documents. Any bubbles or wrinkles that were seen were repaired. During the installation, the saturation mixture of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was observed at 4 to 1, respectively, and the saturation of the carbon fiber was confirmed at 1 quart per 3 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked.

On March 17th and 18th, 2005, several tasks were accomplished to prepare the pipe for the final coat of epoxy bonding agent. First, the proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was verified. Then, the epoxy bonding agent was applied to the edges of the fiber and joints.

On March 19th, 2005, the final coating of the epoxy bonding agent was sprayed on the entire pipe. During the application, the proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was inspected.

On March 21st, 2005, the pipe was checked for voids, and the voids were injected using Injection Resin PRI 2000-1-J-A & B. Finally, the ridges, lines, and splatters in the Cabosil were grinded until smooth.

On March 22nd, 2005, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and observed to be a 3 to 1 ratio, respectively. Then, the first coat of the ARC was applied to the spool. Approximately four to six hours later, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and confirmed at a 3 to 1 ratio, respectively. Then, the second coat of the ARC was applied to the spool.

On March 23rd, 2005, the final inspection was performed on the pipe.

2.2.10. Pipe Spool No. 343A

Pipe size = 120 inches

Pipe length = 16 feet

On March 8th, 2005, during the night shift, the roughness of the sand blasted, concrete surface was verified at ±1/16" amplitude.

On March 9th, 2005, , there were several tasks that were performed to prepare the pipe for the carbon fiber installation. First, excess water and debris were removed, the spool was crack mapped, and the cracks were inspected and found to be clean. While crack mapping, several spiral cracks were found in the pipe (See Appendix A). Then, the cracks were sealed with Injection Resin PRI 2000-1-J-A & B.

On March 10th, 2005, during the night shift, there were a few items that were accomplished to prepare the pipe for the carbon fiber installation. First, ~~the prime coating~~ of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was applied. Before the application of the prime coat, the mixture was confirmed to be at 4 parts of the resin to 1 part of the hardener.

On March 13th, 2005, the carbon fiber installation was started. First, the epoxy bonding agent was applied to the concrete surface, and the spring lines were installed. Then, the first layer of carbon fiber and 5 hoops of the second layer were applied. During the installation, the overlaps of the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction, and the wrap orientation and alignment with the pipe axis were checked. While the fiber was being installed, any bubbles or wrinkles that could be seen were repaired. During the installation, the saturation mixture of Saturating Resin

PRI 2000-3-R-A & 2000-5-HR-B was observed to be at 4 to 1, respectively, and the saturation of the carbon fiber was verified at 1 quart per 3 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked.

On March 14, 2005, the carbon fiber installation was completed. First, six hoops of the second layer of fiber and the termination hoops were laid. While the fiber was applied, the overlaps the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction. Also, the alignment of the fiber was checked to be per contract documents. Any bubbles or wrinkles that were seen were worked out of the fiber. During the installation, the saturation mixture of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was found to be at 4 to 1, respectively, and the saturation of the carbon fiber was observed to be at 1 quart per 3 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked.

On March 17th and 18th, 2005, several tasks were performed to prepare the pipe for the final coat of epoxy bonding agent. First, the proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was inspected. Then, the epoxy bonding agent was applied to the edges of the fiber and joints.

On March 19th, 2005, the final coating of the epoxy bonding agent was sprayed on the entire pipe. During the application, the proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was confirmed.

On March 21st, 2005, the pipe was checked for voids, and the voids were injected using Injection Resin PRI 2000-1-J-A & B. At this time, the ridges, lines, and splatters in the Cabosil were grinded until smooth.

On March 22nd, 2005, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and verified at a 3 to 1 ratio, respectively. Then, the first coat of the ARC was applied to the spool. Approximately four to six hours later, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and confirmed to be a 3 to 1 ratio, respectively. Then, the second coat of the ARC was applied to the spool.

On March 23rd, 2005, the final inspection was performed on the pipe.

2.2.11. Pipe Spool No. 316B

Pipe size = 120 inches

Pipe length = 16 feet

On March 8th, 2005, there were several tasks that were accomplished to prepare the pipe for the carbon fiber installation. During the night shift, the roughness of the sand blasted, concrete surface was inspected and found to be at ±1/16" amplitude. Then, excess water and debris were removed, and the spool was crack mapped. While crack mapping, several hoop cracks were found in the pipe (See Appendix A).

On March 9th, 2005, in preparation for crack injection, the cracks were verified to be clean.

On March 10th, 2005, during the night shift, the cracks were sealed with Injection Resin PRI 2000-1-J-A & B.

On March 14th, 2005, during the night shift, there were a few items that were performed to prepare the pipe for the carbon fiber installation. First, the prime coating of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was applied. Before the application of the prime coat, the mixture was confirmed to be 4 parts of the resin to 1 part of the hardener.

On March 16th, 2005, the carbon fiber installation was started. First, the epoxy bonding agent was applied to the concrete surface, and the spring lines were installed. Then, the first layer of carbon fiber was applied. During the installation, the overlaps of the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction, and the wrap orientation and alignment with the pipe axis were checked. While the fiber was being installed, any bubbles or wrinkles that could be seen were repaired. During the installation, the saturation mixture of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was verified at 4 to 1, respectively, and the saturation of the carbon fiber was observed and found to be at 1 quart per 3 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked.

On March 17th, 2005, during the night shift, the carbon fiber installation was completed. First, the second layer of carbon fiber and the termination hoops were applied. During the installation, the overlaps of the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction, and the wrap orientation and alignment with the pipe axis were checked. While the fiber was being laid, any bubbles or wrinkles that could be seen were fixed. During the installation, the saturation mixture of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was verified at 4 to 1, respectively, and the saturation of the carbon fiber was inspected and found to be at 1 quart per 3 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked.

On March 18th, 2005, during the night shift, several tasks were performed to prepare the pipe for the final coat of epoxy bonding agent. First, the proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was confirmed. Then, the epoxy bonding agent was applied to the edges of the fiber and joints.

On March 19th, 2005, the final coating of the epoxy bonding agent was sprayed on the entire pipe. During the application, the proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was verified. While the epoxy bonding agent was applied, there were areas of the epoxy that "slumped". The ridges on these areas were removed with a grinder before the pipes were coated with the Abrasive Resistive Coating.

On March 21st, 2005, the pipe was checked for voids, and the voids were injected using Injection Resin PRI 2000-1-J-A & B. Next, ridges, lines, and splatters in the Cabosil were grinded until smooth.

On March 22nd, 2005, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and verified at a 3 to 1 ratio, respectively. Then, the first coat of the ARC was applied to the spool.

On March 23rd, 2005, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and observed to be a 3 to 1 ratio, respectively. Then, the second coat of the ARC was applied to the spool. Approximately four to six hours later, the final inspection was performed on the pipe.

2.2.12. Pipe Spool No. 314B

Pipe size = 120 inches

Pipe length = 16 feet

On March 8th, 2005, there were several tasks that were performed to prepare the pipe for the carbon fiber installation. During the night shift, the roughness of the sand blasted, concrete surface was verified at ±1/16" amplitude. Then, excess water and debris were removed, the spool was crack mapped, and the cracks were observed to be clean.. While crack mapping, several hoop cracks were found in the pipe (See Appendix A).

On March 10th, 2005, during the night shift, the cracks were sealed with Injection Resin PRI 2000-1-J-A & B.

On March 14th, 2005, during the night shift, there were a few items that were performed to prepare the pipe for the carbon fiber installation. First, the prime coating of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was applied. Before the application of the prime coat, the mixture was found to be at 4 parts of the resin to 1 part of the hardener.

On March 16th, 2005, during the night shift, the carbon fiber installation was completed. First, the epoxy bonding agent was applied to the concrete surface, and the spring lines were installed. Then, the first layer of carbon fiber was applied. During the installation, the overlaps of the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction, and the wrap orientation and alignment with the pipe axis were checked. While the fiber was being applied, any bubbles or wrinkles that could be seen were repaired. Later, the second layer of carbon fiber and the termination hoops were installed. During the installation, the overlaps of the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction, and the wrap orientation and alignment with the pipe axis were checked. While the fiber was being installed, bubbles and wrinkles that could be seen were worked out of the fiber. During the installation, the saturation mixture of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was inspected and found to be at 4 to 1, respectively, and the saturation of the carbon fiber was verified at 1 quart per 3 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked.

On March 18th, 2005, during the night shift, several tasks were performed to prepare the pipe for the final coat of epoxy bonding agent. First, the proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was observed. Then, the epoxy bonding agent was applied to the edges of the fiber and joints.

On March 19th, 2005, the final coating of the epoxy bonding agent was sprayed on the entire pipe. During the application, the proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was confirmed.

On March 21st, 2005, the pipe was checked for voids, and the voids were injected using Injection Resin PRI 2000-1-J-A & B. During this time, ridges, lines, and splatters in the Cabosil were grinded until smooth.

On March 22nd, 2005, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and verified at a 3 to 1 ratio, respectively. Then, the first coat of the ARC was applied to the spool.

On March 23rd, 2005, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and inspected to be at a 3 to 1 ratio, respectively. Then, the second coat of the ARC was applied to the spool. Approximately four to six hours later, the final inspection was performed on the pipe.

2.2.13. Pipe Spool No. 313A

Pipe size = 120 inches

Pipe length = 16 feet

On March 8th, 2005, there were several tasks that were performed to prepare the pipe for the carbon fiber installation. During the night shift, the roughness of the sand blasted, concrete surface was confirmed to be at ±1/16" amplitude. Then, excess water and debris were removed, and the spool was crack mapped. While crack mapping, several hoop cracks and one longitudinal crack, which needed patching, were found in the pipe (See Appendix A).

On March 9th, 2005, during the night shift, in preparation for crack injection, the cracks were verified to be clean.

On March 10th, 2005, during the night shift, the cracks were sealed with Injection Resin PRI 2000-1-J-A & B.

On March 14th, 2005, during the night shift, there were a few items that were performed to prepare the pipe for the carbon fiber installation. First, the prime coating of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was applied. Before the application of the prime coat, the mixture was found to be at 4 parts of the resin to 1 part of the hardener.

On March 15th, 2005, during the night shift, the carbon fiber installation was completed. First, the epoxy bonding agent was applied to the concrete surface, and the spring lines and a 7'-0" patch were applied. Then, the first layer of carbon fiber was applied. During the installation, the overlaps of the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction, and the wrap orientation and alignment with the pipe axis were checked. While the fiber was being applied, any bubbles or wrinkles that could be seen were fixed. Later, the second layer of carbon fiber and the termination hoops were installed. During the installation, the overlaps of the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction, and the wrap orientation and alignment with the pipe axis were checked. While the fiber was being applied, any bubbles or wrinkles that could be seen were repaired. During the installation, the saturation mixture of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was verified at 4 to 1, respectively, and the saturation of the carbon fiber was observed to be at 1 quart per 3 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked.

On March 18th, 2005, several tasks were performed to prepare the pipe for the final coat of epoxy bonding agent. First, the proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was confirmed. Then, the epoxy bonding agent was applied to the edges of the fiber and joints.

On March 19th, 2005, the final coating of the epoxy bonding agent was sprayed on the entire pipe. During the application, the proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was inspected.

On March 21st, 2005, the pipe was checked for voids, and the voids were injected using Injection Resin PRI 2000-1-J-A & B. Next, any ridges, lines, or splatters in the Cabosil were grinded until smooth.

On March 22nd, 2005, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and found to be at a 3 to 1 ratio, respectively. Then, the first coat of the ARC was applied to the spool.

On March 23rd, 2005, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and inspected and found to be at a 3 to 1 ratio, respectively. Then, the second coat of the ARC was applied to the spool. Approximately four to six hours later, the final inspection was performed on the pipe.

2.2.14. Pipe Spool No. 312B

Pipe size = 120 inches

Pipe length = 16 feet

On March 8th, 2005, there were several tasks that were performed to prepare the pipe for the carbon fiber installation. During the night shift, the roughness of the sand blasted, concrete surface was verified at ±1/16" amplitude. Then, excess water and debris were removed, and the spool was crack mapped. While crack mapping, several longitudinal cracks which needed to be patched were found in the pipe (See Appendix A).

On March 9th, 2005, during the night shift, in preparation for crack injection, the cracks were observed to be clean.

On March 10th, 2005, during the night shift, the cracks were sealed with Injection Resin PRI 2000-1-J-A & B.

On March 14th, 2005, during the night shift, there were a few items that were performed to prepare the pipe for the carbon fiber installation. First, the prime coating of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B ~~was~~ applied. Before the application of the prime coat, the mixture was confirmed to be 4 parts of the resin to 1 part of the hardener.

On March 16th, 2005, during the night shift, the carbon fiber installation was started. First, the epoxy bonding agent was applied to the concrete surface, and the spring lines, two 16'-0" patches, and one 8'-0" patch were installed. Then, the first layer of carbon fiber was applied. During the installation, the overlaps of the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction, and the wrap orientation and alignment with the pipe axis were checked. While the fiber was being installed, any bubbles or wrinkles that could be seen were fixed. During the installation, the saturation mixture of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was observed to be 4 to 1, respectively, and the saturation of the carbon fiber was verified at 1 quart per 3 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked.

On March 17, 2005, during the night shift, the carbon fiber installation was completed. First, the second layer of fiber and the termination hoops were installed. While the fiber was laid, the overlaps the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction. Also, the alignment of the fiber was checked to be per contract documents. Any bubbles or wrinkles that were seen were repaired. During the installation, the saturation mixture of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was inspected and found to be 4 to 1, respectively, and the saturation of the carbon fiber was confirmed to be 1 quart per 3 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked.

On March 18th, 2005, several tasks were accomplished to prepare the pipe for the final coat of epoxy bonding agent. First, the proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was inspected. Then, the epoxy bonding agent was applied to the edges of the fiber and joints.

On March 19th, 2005, the final coating of the epoxy bonding agent was sprayed on the entire pipe. During the application, the proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was observed.

On March 21st, 2005, the pipe was checked for voids, and the voids were injected using Injection Resin PRI 2000-1-J-A & B. At this time, any ridges, lines, or splatters in the Cabosil were grinded until smooth.

On March 22nd, 2005, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and found to be a 3 to 1 ratio, respectively. Then, the first coat of the ARC was applied to the spool. Approximately four to six hours later, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and verified at a 3 to 1 ratio, respectively. Then, the second coat of the ARC was applied to the spool.

On March 23rd, 2005, the final inspection was performed on the pipe.

2.3. Access Manhole No. 1B

Figure 4: Spool 41 Looking Away From Manhole 1B

2.3.1. Pipe Spool No. 5

Pipe size	=	120 inches
Pipe length	=	16 feet

On March 8th, 2005, there were several tasks that were accomplished to prepare the pipe for the carbon fiber installation. During the night shift, the roughness of the sand blasted, concrete surface was observed to be at ±1/16" amplitude. Then, excess water and debris were removed, and the spool was crack mapped. While crack mapping, several hoop cracks were found in the pipe (See Appendix A).

On March 10th, 2005, during the night shift, in preparation for crack injection, the cracks were confirmed to be clean, and the cracks were sealed with Injection Resin PRI 2000-1-J-A & B.

On March 11th, 2005, during the night shift, there were a few items that were performed to prepare the pipe for the carbon fiber installation and the carbon fiber was started. First, the prime coating of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was applied. Before the application of the prime coat, the mixture was inspected and found to be 4 parts of the resin to 1 part of the hardener. One hour later, the epoxy bonding agent was applied to the concrete surface, and the spring lines and one hoop on the first layer were applied.

On March 11th, 2005, during the night shift, the carbon fiber installation was completed. First, seven hoops of the first layer of carbon fiber were applied. During the installation, the overlaps of the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction, and the wrap orientation and alignment with the pipe axis were checked. While the fiber was being installed, any bubbles or wrinkles that could be seen were repaired. Later, the second layer of carbon fiber and the termination hoops were installed. During the installation, the overlaps of the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction, and the wrap orientation and alignment with the pipe axis were checked. While the fiber was being laid, any bubbles or wrinkles that could be seen were fixed. During the installation, the saturation mixture of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was verified at 4 to 1, respectively, and the saturation of the carbon fiber was found to be at 1 quart per 3 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked.

On March 19th, 2005, several tasks were performed to prepare the pipe for the final coat of epoxy bonding agent. First, the proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was observed. Then, the epoxy bonding agent was applied to the edges of the fiber and joints.

On March 20th, 2005, the final coating of the epoxy bonding agent was sprayed on the entire pipe. During the application, the proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was inspected.

On March 21st, 2005, the pipe was checked for voids, and the voids were injected using Injection Resin PRI 2000-1-J-A & B. At this time, any ridges, lines, or splatters in the Cabosil were grinded until smooth. Four to six hours later, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and confirmed to be a 3 to 1 ratio, respectively. Then, the first coat of the ARC was sprayed on the entire spool.

On March 22nd, 2005, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and verified at a 3 to 1 ratio, respectively. Then, the second coat of the ARC was applied to the spool.

On March 23rd, 2005, the final inspection was performed on the pipe.

2.3.2. Pipe Spool No. 8

Pipe size	=	120 inches
Pipe length	=	16 feet

On March 8th, 2005, there were several tasks that were accomplished to prepare the pipe for the carbon fiber installation. During the night shift, the roughness of the sand blasted, concrete surface was inspected and found to be at ±1/16" amplitude. Then, excess water and debris were removed, the spool was crack mapped, and the cracks were confirmed to be clean. While crack mapping, several hoop cracks were found in the pipe along with one longitudinal crack that needed a patch (See Appendix A).

On March 10th, 2005, during the night shift, there were a few items that were performed to prepare the pipe for the carbon fiber installation. First, the cracks were sealed with Injection Resin PRI 2000-1-J-A & B. Then, the prime coating of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was applied. Before the application of the prime coat, the mixture was confirmed to be 4 parts of the resin to 1 part of the hardener. One hour later, the epoxy bonding agent was applied to the concrete surface, and the spring lines were applied.

On March 12th, 2005, during the night shift, the carbon fiber installation was continued. First, the first layer of carbon fiber was applied. During the installation, the overlaps of the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction, and the wrap orientation and alignment with the pipe axis were checked. While the fiber was being installed, any bubbles or wrinkles that could be seen were worked out of the fiber.

On March 13th, 2005, during the night shift, the carbon fiber installation was completed. First, the second layer of carbon fiber and the termination hoops were installed. During the installation, the overlaps of the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction, and the wrap orientation and alignment with the pipe axis were checked. While the fiber was being applied, any bubbles or wrinkles that could be seen were repaired. During the installation, the saturation mixture of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was verified at 4 to 1, respectively, and the saturation of the carbon fiber was inspected and found to be 1 quart per 3 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked.

On March 19th, 2005, several tasks were performed to prepare the pipe for the final coat of epoxy bonding agent. First, the proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was observed. Then, the epoxy bonding agent was applied to the edges of the fiber and joints.

On March 20th, 2005, the final coating of the epoxy bonding agent was sprayed on the entire pipe. During the application, the proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was confirmed.

On March 21st, 2005, the pipe was checked for voids, and the voids were injected using Injection Resin PRI 2000-1-J-A & B. During this time, any ridges, lines, or splatters in the Cabosil were grinded until smooth. After four to six hours, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and verified at a 3 to 1 ratio, respectively. Then, the first coat of the ARC was sprayed on the entire spool.

On March 22rd, 2005, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and found to be a 3 to 1 ratio, respectively. Then, the second coat of the ARC was applied to the spool.

On March 23rd, 2005, the final inspection was performed on the pipe.

2.3.3. Pipe Spool No. 13

Pipe size = 120 inches

Pipe length = 16 feet

On March 8th, 2005, during the night shift, the roughness of the sand blasted, concrete surface was verified at ±1/16" amplitude.

On March 9th, 2005, there were several tasks that were accomplished to prepare the pipe for the carbon fiber installation. During the night shift, excess water and debris were removed, and the spool was crack mapped. While crack mapping, several hoop cracks were found in the pipe (See Appendix A).

On March 10th, 2005, during the night shift, there were a few items that were performed to prepare the pipe for the crack injection. First, the cracks were observed to be clean, and the cracks were sealed with Injection Resin PRI 2000-1-J-A & B.

On March 13th, 2005, during the night shift, there were a few items that were performed to prepare the pipe for the carbon fiber. First, the prime coating of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was applied. Before the application of the prime coat, the mixture was found to be at 4 parts of the resin to 1 part of the hardener.

On March 14th, 2005, during the night shift, the carbon fiber installation was completed. First, the epoxy bonding agent was applied to the concrete surface, and the spring lines were installed. Then, the first layer of carbon fiber was applied. During the installation, the overlaps of the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction, and the wrap orientation and alignment with the pipe axis were checked. While the fiber was being applied, any bubbles or wrinkles that could be seen were repaired. Finally, the second layer of carbon fiber and the termination hoops were installed. During the installation, the overlaps of the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction, and the wrap orientation and alignment with the pipe axis were checked. While the fiber was being installed, any bubbles or wrinkles that could be seen were fixed. During the installation, the saturation mixture of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was observed to be at 4 to 1, respectively, and the saturation of the carbon fiber was inspected and found to be at 1 quart per 3 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked.

On March 19th, 2005, several tasks were performed to prepare the pipe for the final coat of epoxy bonding agent. First, the proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was confirmed. Then, the epoxy bonding agent was applied to the edges of the fiber and joints.

On March 20th, 2005, the final coating of the epoxy bonding agent was sprayed on the entire pipe. During the application, the proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was inspected.

On March 21st, 2005, the pipe was checked for voids, and the voids were injected using Injection Resin PRI 2000-1-J-A & B. Next, any ridges, lines, or splatters in the Cabosil were grinded until smooth. Four to six hours later, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and found to be a 3 to 1 ratio, respectively. Then, the first coat of the ARC was sprayed on the entire spool.

On March 22nd, 2005, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and confirmed to be a 3 to 1 ratio, respectively. Then, the second coat of the ARC was applied to the spool.

On March 23rd, 2005, the final inspection was performed on the pipe.

2.3.4. Pipe Spool No. 16

Pipe size	=	120 inches
Pipe length	=	16 feet

On March 8th, 2005, during the night shift, the roughness of the sand blasted, concrete surface was found to be at ±1/16" amplitude and the excess water and debris were removed.

On March 9th, 2005, there were several tasks that were accomplished to prepare the pipe for the carbon fiber installation. During the night shift, the spool was crack mapped, and the , the cracks were verified to be clean. While crack mapping, several longitudinal cracks which needed patching were found in the pipe (See Appendix A).

On March 10th, 2005, during the night shift, there were a few items that were finalized for the preparation of the installation of the carbon fiber. First, the cracks were sealed with Injection Resin PRI 2000-1-J-A & B. Then, the prime coating of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was applied. Before the application of the prime coat, the mixture was confirmed to be 4 parts of the resin to 1 part of the hardener.

On March 13th, 2005, during the night shift, the carbon fiber installation was started. First, the epoxy bonding agent was applied to the concrete surface, and the spring lines, a 6'-0" patch, and a 8'-0" patch were applied for the cracks mentioned above. Then, the first layer of carbon fiber was applied. During the installation, the overlaps of the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction, and the wrap orientation and alignment with the pipe axis were checked. While the fiber was being laid, any bubbles or wrinkles that could be seen were repaired.

During the installation, the saturation mixture of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was observed to be at 4 to 1, respectively, and the saturation of the carbon fiber was verified at 1 quart per 3 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked.

On March 14th, 2005, during the night shift, the carbon fiber installation was completed. First, the second layer of carbon fiber was applied. During the installation, the overlaps of the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction, and the wrap orientation and alignment with the pipe axis were checked. While the fiber was being installed, any bubbles or wrinkles that could be seen were fixed. During the installation, the saturation mixture of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was inspected and found to be at 4 to 1, respectively, and the saturation of the carbon fiber was verified at 1 quart per 3 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked.

On March 19th, 2005, several tasks were performed to prepare the pipe for the final coat of epoxy bonding agent. First, the proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was confirmed. Then, the epoxy bonding agent was applied to the edges of the fiber and joints.

On March 20th, 2005, the final coating of the epoxy bonding agent was sprayed on the entire pipe. During the application, the proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was observed.

On March 21st, 2005, the pipe was checked for voids, and the voids were injected using Injection Resin PRI 2000-1-J-A & B. At this time, any ridges, lines, or splatters in the Cabosil were grinded until smooth. After waiting four to six hours, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and verified at a 3 to 1 ratio, respectively. Then, the first coat of the ARC was sprayed on the entire spool.

On March 22rd, 2005, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and inspected and found to be a 3 to 1 ratio, respectively. Then, the second coat of the ARC was applied to the spool.

On March 23rd, 2005, the final inspection was performed on the pipe.

2.3.5. Pipe Spool No. 17

Pipe size = 120 inches

Pipe length = 16 feet

On March 8th, 2005, during the night shift, the roughness of the sand blasted, concrete surface was observed to be at ±1/16" amplitude and the excess water and debris were removed.

On March 9th, 2005, there were several tasks that were accomplished to prepare the pipe for the carbon fiber installation. During the night shift, the spool was crack mapped, and the cracks were observed to be clean. While crack mapping, several longitudinal cracks that needed patching were found in the pipe (See Appendix A).

On March 10th, 2005, during the night shift, the cracks were sealed with Injection Resin PRI 2000-1-J-A & B.

On March 12th, 2005, there were several tasks completed for the preparation for the carbon fiber installation. First, the prime coating of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was applied. Before the application of the prime coat, the mixture was inspected and found to be at 4 parts of the resin to 1 part of the hardener.

On March 13th, 2005, during the night shift, the carbon fiber installation was started. First, the epoxy bonding agent was applied to the concrete surface, and the spring lines, a 12'-0" patch, and a 16'-0" patch were installed for the cracks mentioned above. Next, the first layer of carbon fiber, the second layer of carbon fiber, and the termination hoops were applied. During the installation, the overlaps of the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction, and the wrap orientation and alignment with the pipe axis were checked. While the fiber was being applied, any bubbles or wrinkles that could be seen were repaired. During the installation, the saturation mixture of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was confirmed to be at 4 to 1, respectively, and the saturation of the carbon fiber was verified at 1 quart per 3 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked.

On March 19th, 2005, several tasks were performed to prepare the pipe for the final coat of epoxy bonding agent. First, the proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was inspected. Then, the epoxy bonding agent was applied to the edges of the fiber and joints.

On March 20th, 2005, the final coating of the epoxy bonding agent was sprayed on the entire pipe. During the application, the proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was confirmed.

On March 21st, 2005, the pipe was checked for voids, and the voids were injected using Injection Resin PRI 2000-1-J-A & B. During this time, any ridges, lines, or splatters in the Cabosil were grinded until smooth. Four to six hours later, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and observed to be at a 3 to 1 ratio, respectively. Then, the first coat of the ARC was sprayed on the entire spool.

On March 22rd, 2005, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and verified at a 3 to 1 ratio, respectively. Then, the second coat of the ARC was applied to the spool.

On March 23rd, 2005, the final inspection was performed on the pipe.

2.3.6. Pipe Spool No. 19

Pipe size = 120 inches

Pipe length = 16 feet

On March 8th, 2005, during the night shift, the roughness of the sand blasted, concrete surface was verified at ±1/16" amplitude and the excess water and debris were removed.

On March 9th, 2005, there were several tasks that were accomplished to prepare the pipe for the carbon fiber installation. During the night shift, the spool was crack mapped, and the cracks were confirmed to be clean. While crack mapping, several hoop cracks were found in the pipe (See Appendix A).

On March 10th, 2005, during the night shift, there were a few items that were completed for crack injection. First, the cracks were sealed with Injection Resin PRI 2000-1-J-A & B.

On March 13th, 2005, during the night shift, there were a few items that were finalized in the preparation for the installation of carbon fiber. First, the prime coating of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was applied. Before the application of the prime coat, the mixture was observed to be at 4 parts of the resin to 1 part of the hardener.

On March 15th, 2005, during the night shift, the carbon fiber installation was completed. First, the epoxy bonding agent was applied to the concrete surface, and the spring lines were installed. Next, the first layer of carbon fiber, the second layer of carbon fiber, and the termination hoops were applied. During the installation, the overlaps of the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction, and the wrap orientation and alignment with the pipe axis were checked. While the fiber was being laid, any bubbles or wrinkles that could be seen were worked out of the fiber. During the installation, the saturation mixture of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was inspected and found to be at 4 to 1, respectively, and the saturation of the carbon fiber was verified at 1 quart per 3 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked.

On March 19th, 2005, several tasks were performed to prepare the pipe for the final coat of epoxy bonding agent. First, the proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was confirmed. Then, the epoxy bonding agent was applied to the edges of the fiber and joints.

On March 20th, 2005, the final coating of the epoxy bonding agent was sprayed on the entire pipe. During the application, the proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was observed.

On March 21st, 2005, the pipe was checked for voids, and the voids were injected using Injection Resin PRI 2000-1-J-A & B. At this time, any ridges, lines, or splatters in the Cabosil were grinded until smooth. Next, after four to six hours, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and verified at a 3 to 1 ratio, respectively. Then, the first coat of the ARC was sprayed on the entire spool.

On March 22rd, 2005, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and confirmed to be at a 3 to 1 ratio, respectively. Then, the second coat of the ARC was applied to the spool.

On March 23rd, 2005, the final inspection was performed on the pipe.

2.3.7. Pipe Spool No. 21

Pipe size	=	120 inches
Pipe length	=	16 feet

On March 8th, 2005, during the night shift, the roughness of the sand blasted, concrete surface was observed to be at ±1/16" amplitude and the excess water and debris were removed.

On March 9th, 2005, there were several tasks that were accomplished to prepare the pipe for the carbon fiber installation. During the night shift, the spool was crack mapped. While crack mapping, several hoop cracks were found in the pipe (See Appendix A).

On March 10th, 2005, during the night shift, there were a few items that were completed for crack injection. First, the cracks were verified to be clean. Then, the cracks were sealed with Injection Resin PRI 2000-1-J-A & B.

On March 13th, 2005, during the night shift, there were a few items that were finalized in the preparation for the installation of carbon fiber. First, the prime coating of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was applied. Before the application of the prime coat, the mixture was confirmed to be at 4 parts of the resin to 1 part of the hardener.

On March 15th, 2005, during the night shift, the carbon fiber installation was started. First, the epoxy bonding agent was applied to the concrete surface, and the spring lines were installed. Next, the first layer of carbon fiber was applied. During the installation, the overlaps of the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction, and the wrap orientation and alignment with the pipe axis were checked. While the fiber was being applied, any bubbles or wrinkles that could be seen were fixed. During the installation, the saturation mixture of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was inspected and found to be at 4 to 1, respectively, and the saturation of the carbon fiber was verified at 1 quart per 3 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked.

On March 16th, 2005, during the night shift, the carbon fiber installation was completed. First, the second layer of carbon fiber and the termination hoops were applied. During the installation, the overlaps of the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction, and the wrap orientation and alignment with the pipe axis were checked. While the fiber was being installed, any bubbles or wrinkles that could be seen were repaired. During the installation, the saturation mixture of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was observed to be at 4 to 1, respectively, and the saturation of the carbon fiber was confirmed to be at 1 quart per 3 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked.

On March 19th, 2005, several tasks were performed to prepare the pipe for the final coat of epoxy bonding agent. First, the proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was observed. Then, the epoxy bonding agent was applied to the edges of the fiber and joints.

On March 20th, 2005, the final coating of the epoxy bonding agent was sprayed on the entire pipe. During the application, the proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was inspected.

On March 21st, 2005, the pipe was checked for voids, and the voids were injected using Injection Resin PRI 2000-1-J-A & B. At this time, any ridges, lines, or splatters found in the Cabosil were grinded until smooth. Then, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and verified at a 3 to 1 ratio, respectively. Finally, the first coat of the ARC was sprayed on the entire spool.

On March 22rd, 2005, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and inspected and found to be at a 3 to 1 ratio, respectively. Then, after four to six hours, the second coat of the ARC was applied to the spool.

On March 23rd, 2005, the final inspection was performed on the pipe.

2.3.8. Pipe Spool No. 35

Pipe size	=	120 inches
Pipe length	=	16 feet

On March 9th, 2005, there were several tasks that were accomplished to prepare the pipe for the carbon fiber installation. First, the roughness of the sand blasted, concrete surface was verified at ±1/16" amplitude, and the excess water and debris were removed. Next, the spool was crack mapped, and the cracks were confirmed to be clean. While crack mapping, several hoop cracks and a spiral crack, which required patching, were found in the pipe (See Appendix A). Then, the cracks were sealed with Injection Resin PRI 2000-1-J-A & B. Finally, the prime coating of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was applied. Before the application of the prime coat, the mixture was observed to be at 4 parts of the resin to 1 part of the hardener.

On March 10th, 2005, the carbon fiber installation was started. First, the epoxy bonding agent was applied to the concrete surface, the spring lines were applied, and a 32'-0" patch were installed. Next, the first layer of carbon fiber was applied. During the installation, the overlaps of the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction, and the wrap orientation and alignment with the pipe axis were checked. While the fiber was being applied, any bubbles or wrinkles that could be seen were repaired. During the installation, the saturation mixture of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was inspected and found to be at 4 to 1, respectively, and the saturation of the carbon fiber was confirmed to be at 1 quart per 3 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked.

On March 11th, 2005, [redacted] that [redacted] the [redacted] the [redacted]. [redacted] that [redacted] hollow were inject[redacted] B.

On March 12th, 2005, the carbon fiber installation was completed. First, the second layer of carbon fiber and the termination hoops were applied. During the installation, the overlaps of the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction, and the wrap orientation and alignment with the pipe axis were checked. While the fiber was being laid, any bubbles or wrinkles that could be seen were fixed. During the installation, the saturation mixture of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was verified at 4 to 1, respectively, and the saturation of the carbon fiber was observed to be at 1 quart per 3 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked.

On March 19th, 2005, several tasks were performed to prepare the pipe for the final coat of epoxy bonding agent. First, the proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was confirmed. Then, the epoxy bonding agent was applied to the edges of the fiber and joints.

On March 20th, 2005, the final coating of the epoxy bonding agent was sprayed on the entire pipe. During the application, the proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was inspected.

On March 21st, 2005, the pipe was rechecked for voids, and the voids were injected using Injection Resin PRI 2000-1-J-A & B. During this time, any splatters, ridges, or lines found in the Cabosil were grinded until smooth. After four to six hours, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and confirmed to be at a 3 to 1 ratio, respectively. Then, the first coat of the ARC was sprayed on the entire spool.

On March 22rd, 2005, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and inspected and found to be at a 3 to 1 ratio, respectively. Then, the second coat of the ARC was applied to the spool.

On March 23rd, 2005, the final inspection was performed on the pipe.

2.3.9. Pipe Spool No. 36

Pipe size = 120 inches

Pipe length = 16 feet

On March 9th, 2005, there were several tasks that were accomplished to prepare the pipe for the carbon fiber installation. First, the roughness of the sand blasted, concrete surface was confirmed to be at ±1/16" amplitude, and the excess water and debris were removed. Next, the spool was crack mapped, and the cracks were confirmed to be clean. While crack mapping, several hoop cracks and two longitudinal cracks, which required patching, were found in the pipe (See Appendix A). Then, the cracks were sealed with Injection Resin PRI 2000-1-J-A & B.

On March 10th, 2005, the prime coating of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was applied to the tops and sides of the pipe. Before the application of the prime coat, the mixture was inspected and found to be at 4 parts of the resin to 1 part of the hardener.

On March 11th, 2005, the pipe bottom was prepared for the installation of the carbon fiber and the carbon fiber was started. First, the prime coating of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was applied to the bottom of the pipe. Before the application of the prime coat, the mixture was observed to be at 4 parts of the resin to 1 part of the hardener. Next, the epoxy bonding agent was applied to the concrete surface, the spring lines were applied, and two 16'-0" patches were installed. During the installation, the saturation mixture of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was confirmed to be at 4 to 1, respectively, and the saturation of the carbon fiber was verified at 1 quart per 3 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked

On March 12th, 2005, the carbon fiber installation continued. First, the first layer of carbon fiber was applied. During the installation, the overlaps of the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction, and the wrap orientation and alignment with the pipe axis were checked. While the fiber was being installed, any bubbles or wrinkles that could be seen were worked out of the fiber. During the installation, the saturation mixture of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was inspected and found to be at 4 to 1, respectively, and the saturation of the carbon fiber was confirmed to be at 1 quart per 3 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked.

On March 14th, 2005, the carbon fiber installation was completed. First, the second layer of carbon fiber and the termination hoops were applied. During the installation, the overlaps of the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction, and the wrap orientation and alignment with the pipe axis were checked. While the fiber was being applied, any bubbles or wrinkles that could be seen were repaired. During the application, the saturation mixture of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was verified at 4 to 1, respectively, and the saturation of the carbon fiber was observed to be at 1 quart per 3 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked.

On March 19th, 2005, several tasks were performed to prepare the pipe for the final coat of epoxy bonding agent. First, the proper mixing of epoxy bonding agent using

Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was confirmed. Then, the epoxy bonding agent was applied to the edges of the fiber and joints.

On March 20th, 2005, the final coating of the epoxy bonding agent was sprayed on the entire pipe. During the application, the proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was verified.

On March 21st, 2005, the pipe was checked for voids, and the voids were injected using Injection Resin PRI 2000-1-J-A & B. At this time, lines, ridges, or splatters found in the Cabosil were grinded until smooth. Four to six hours later, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and inspected and found to be at a 3 to 1 ratio, respectively. Finally, the first coat of the ARC was sprayed on the entire spool.

On March 22rd, 2005, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and observed to be at a 3 to 1 ratio, respectively. Then, the second coat of the ARC was applied to the spool.

On March 23rd, 2005, the final inspection was performed on the pipe.

2.3.10. Pipe Spool No. 37

Pipe size = 120 inches

Pipe length = 16 feet

On March 9th, 2005, there were several tasks that were accomplished to prepare the pipe for the carbon fiber installation. First, the roughness of the sand blasted, concrete surface was verified at ±1/16" amplitude, and the excess water and debris were removed. Next, the spool was crack mapped, and the cracks were observed to be clean. While crack mapping, several hoop cracks and three longitudinal cracks, which required patching, were found in the pipe (See Appendix A). Then, the cracks were sealed with Injection Resin PRI 2000-1-J-A & B.

On March 10th, 2005, the prime coating of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was applied to the tops and sides of the pipe. Before the application of the prime coat, the mixture was verified at 4 parts of the resin to 1 part of the hardener.

On March 11th, 2005, the pipe bottom was prepared for the installation of the carbon fiber and the carbon fiber was started. First, the prime coating of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was applied to the bottom of the pipe. Before the application of the prime coat, the mixture was checked and found to be at 4 parts of the resin to 1 part of the hardener. After one hour, the epoxy bonding agent was applied to the concrete surface, the spring lines were applied, and a 16'-0" patch, 12'-0" patch, and a 8'-0" patch were installed. Then, the first layer of carbon fiber was applied. During the installation, the overlaps of the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction, and the wrap orientation and alignment with the pipe axis were checked. While the fiber was being laid, any bubbles or wrinkles that could be seen were fixed. During the installation, the saturation mixture of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was observed to be at 4 to 1, respectively, and the saturation of the carbon fiber was confirmed to be at 1 quart per 3 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked

On March 12th, 2005, the carbon fiber application was completed. First, the second layer of carbon fiber and the termination hoops were applied. During the installation, the overlaps of the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction, and the wrap orientation and alignment with the pipe axis were checked. While the fiber was being installed, any bubbles or wrinkles that could be seen were worked out of the fiber. During the installation, the saturation mixture of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was inspected and found to be at 4 to 1, respectively, and the saturation of the carbon fiber was confirmed to be at 1 quart per 3 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked.

On March 19th, 2005, several tasks were performed to prepare the pipe for the final coat of epoxy bonding agent. First, the proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was observed. Then, the epoxy bonding agent was applied to the edges of the fiber and joints.

On March 20th, 2005, the final coating of the epoxy bonding agent was sprayed on the entire pipe. During the application, the proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was inspected.

On March 21st, 2005, the pipe was checked for voids, and the voids were injected using Injection Resin PRI 2000-1-J-A & B. Then, the ridges, lines and splatters in the Cabosil were grinded smooth. Next, after four to six hours, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and confirmed to be at a 3 to 1 ratio, respectively. Then, the first coat of the ARC was sprayed on the entire spool.

On March 22nd, 2005, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and verified at a 3 to 1 ratio, respectively. Then, the second coat of the ARC was applied to the spool.

On March 23rd, 2005, the final inspection was performed on the pipe.

2.3.11. Pipe Spool No. 38

Pipe size = 120 inches

Pipe length = 16 feet

On March 9th, 2005, there were several tasks that were accomplished to prepare the pipe for the carbon fiber application. First, the roughness of the sand blasted, concrete surface was verified at ±1/16" amplitude, and the excess water and debris were removed. Next, the spool was crack mapped, and the cracks were confirmed to be clean. While crack mapping, several hoop cracks were found in the pipe (See Appendix A). Then, the cracks were sealed with Injection Resin PRI 2000-1-J-A & B.

On March 10th, 2005, the prime coating of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was applied to the tops and sides of the pipe. Before the application of the prime coat, the mixture was observed to be at 4 parts of the resin to 1 part of the hardener.

On March 12th, 2005, the pipe bottom was prepared for the installation of the carbon fiber and the carbon fiber was started. First, the prime coating of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was applied to the bottom of the pipe. Before the application of the prime coat, the mixture was inspected and found to be at 4 parts of the resin to 1 part of the hardener. After one hour, the epoxy bonding agent was applied to the concrete surface, and the spring lines were applied. Then, the first layer of carbon fiber was applied. During the application, the overlaps of the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction, and the wrap orientation and alignment with the pipe axis were checked. While the fiber was being installed, any bubbles or wrinkles that could be seen were repaired. During the installation, the saturation mixture of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was verified at 4 to 1, respectively, and the saturation of the carbon fiber was confirmed to be at 1 quart per 3 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked

On March 14th, 2005, the carbon fiber installation was completed. First, the second layer of carbon fiber and the termination hoops were applied. During the application, the overlaps of the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction, and the wrap orientation and alignment with the pipe axis were checked. While the fiber was being installed, any bubbles or wrinkles that could be seen were fixed. During the installation, the saturation mixture of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was observed to be at 4 to 1, respectively, and the saturation of the carbon fiber was verified at 1 quart per 3 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked.

On March 19th, 2005, several tasks were performed to prepare the pipe for the final coat of epoxy bonding agent. First, the proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was inspected. Then, the epoxy bonding agent was applied to the edges of the fiber and joints.

On March 20th, 2005, the final coating of the epoxy bonding agent was sprayed on the entire pipe. During the application, the proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was observed.

On March 21st, 2005, the pipe was checked for voids, and the voids were injected using Injection Resin PRI 2000-1-J-A & B. Then, the ridges, lines and splatters in the

Cabosil were grinded smooth. Four to six hours later, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and confirmed to be at a 3 to 1 ratio, respectively. Then, the first coat of the ARC was sprayed on the entire spool.

On March 22[rd], 2005, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and inspected and found to be at a 3 to 1 ratio, respectively. Then, the second coat of the ARC was applied to the spool.

On March 23[rd], 2005, the final inspection was performed on the pipe.

2.3.12. Pipe Spool No. 39

Pipe size = 120 inches

Pipe length = 16 feet

On March 9th, 2005, there were several tasks that were accomplished to prepare the pipe for the carbon fiber installation. First, the roughness of the sand blasted, concrete surface was observed to be at ±1/16" amplitude and the excess water and debris were removed. Next, the spool was crack mapped, and the cracks were inspected and found to be clean. While crack mapping, several hoop cracks were found in the pipe (See Appendix A). Then, the cracks were sealed with Injection Resin PRI 2000-1-J-A & B.

On March 10th, 2005, the preparation of the pipe for the carbon fiber installation was finalized, and the carbon fiber application started. First, the prime coating of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was applied. Before the application of the prime coat, the mixture was confirmed to be at 4 parts of the resin to 1 part of the hardener. After one hour, the epoxy bonding agent was applied to the concrete surface, and the spring lines were applied. While the fiber was being laid, any bubbles or wrinkles that could be seen were repaired. During the installation, the saturation mixture of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was verified at 4 to 1, respectively, and the saturation of the carbon fiber was observed to be at 1 quart per 3 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked

On March 11th, 2005, the carbon fiber application continued. First, the first layer of carbon fiber was applied. During the installation, the overlaps of the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction, and the wrap orientation and alignment with the pipe axis were checked. While the fiber was being installed, any bubbles or wrinkles that could be seen were fixed. During the installation, the saturation mixture of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was confirmed to be at 4 to 1, respectively, and the saturation of the carbon fiber was observed to be at 1 quart per 3 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked

On March 12th, 2005, the carbon fiber application was completed. First, the second layer of carbon fiber and the termination hoops were applied. During the installation, the overlaps of the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction, and the wrap orientation and alignment with the pipe axis were checked. While the fiber was being installed, any bubbles or wrinkles that could be seen were repaired. During the installation, the saturation mixture of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was verified at 4 to 1, respectively, and the saturation of the carbon fiber was inspected and found to be at 1 quart per 3 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked.

On March 19th, 2005, several tasks were performed to prepare the pipe for the final coat of epoxy bonding agent. First, the proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was confirmed. Then, the epoxy bonding agent was applied to the edges of the fiber and joints.

On March 20th, 2005, the final coating of the epoxy bonding agent was sprayed on the entire pipe. During the application, the proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was observed.

On March 21st, 2005, the pipe was checked for voids, and the voids were injected using Injection Resin PRI 2000-1-J-A & B. Then, the ridges, lines and splatters in the Cabosil were grinded smooth. After four to six hours, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and verified at a 3 to 1 ratio, respectively. Then, the first coat of the ARC was sprayed on the entire spool.

On March 22rd, 2005, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and verified at a 3 to 1 ratio, respectively. Then, the second coat of the ARC was applied to the spool.

On March 23rd, 2005, the final inspection was performed on the pipe.

2.3.13. Pipe Spool No. 41

Pipe size = 120 inches

Pipe length = 16 feet

On March 9th, 2005, there were several tasks that were performed to prepare the pipe for the carbon fiber installation. First, the roughness of the sand blasted, concrete surface was observed to be at ±1/16" amplitude and the excess water and debris were removed. Next, the spool was crack mapped, and the cracks were inspected to be clean. While crack mapping, several hoop cracks and two longitudinal cracks, which need patching, were found in the pipe (See Appendix A). Then, the cracks were sealed with Injection Resin PRI 2000-1-J-A & B.

On March 12th, 2005, the preparation of the pipe for the carbon fiber application was finalized, and the carbon fiber installation started. First, the prime coating of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was applied. Before the application of the prime coat, the mixture was confirmed to be at 4 parts of the resin to 1 part of the hardener. After one hour, the epoxy bonding agent was applied to the concrete surface, and two 16'-0" patches were applied. While the fiber was being installed, any bubbles or wrinkles that could be seen were worked out of the fiber. During the installation, the saturation mixture of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was verified at 4 to 1, respectively, and the saturation of the carbon fiber was verified at 1 quart per 3 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked

On March 15th, 2005, the carbon fiber application continued. First, the spring lines and the first layer of carbon fiber were applied. During the installation, the overlaps of the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction, and the wrap orientation and alignment with the pipe axis were checked. While the fiber was being laid, any bubbles or wrinkles that could be seen were repaired. During the installation, the saturation mixture of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was observed to be at 4 to 1, respectively, and the saturation of the carbon fiber was confirmed to be at 1 quart per 3 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked

On March 17th, 2005, the carbon fiber application was completed. First, the second layer of carbon fiber and the termination hoops were applied. During the installation, the overlaps of the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction, and the wrap orientation and alignment with the pipe axis were checked. While the fiber was being applied, any bubbles or wrinkles that could be seen were fixed. During the installation, the saturation mixture of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was verified at 4 to 1, respectively, and the saturation of the carbon fiber was inspected and found to be at 1 quart per 3 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked.

On March 19th, 2005, several tasks were performed to prepare the pipe for the final coat of epoxy bonding agent. First, the proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was verified. Then, the epoxy bonding agent was applied to the edges of the fiber and joints.

On March 20th, 2005, the final coating of the epoxy bonding agent was sprayed on the entire pipe. During the application, the proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was inspected.

On March 21st, 2005, the pipe was checked for voids; and the voids were injected using Injection Resin PRI 2000-1-J-A & B. Then, the ridges, lines and splatters in the Cabosil were grinded smooth. Next, four to six hours later, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and confirmed to be at a 3 to 1 ratio, respectively. Finally, the first coat of the ARC was sprayed on the entire spool.

On March 22rd, 2005, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and verified at a 3 to 1 ratio, respectively. Then, the second coat of the ARC was applied to the spool.

On March 23rd, 2005, the final inspection was performed on the pipe.

2.3.14. Pipe Spool No. 53

Pipe size = 114 inches

Pipe length = 15.93 feet

On March 9th, 2005, there were several tasks that were accomplished to prepare the pipe for the carbon fiber application. First, the roughness of the sand blasted, concrete surface was inspected and found to be at ±1/16" amplitude and the excess water and debris were removed. Next, the spool was crack mapped, and the cracks were observed to be clean. While crack mapping, major spiral and longitudinal cracks were found in the pipe (See Appendix A). Then, the cracks were sealed with Injection Resin PRI 2000-1-J-A & B. Due to the extensive amount of cracks in the pipe, another layer of fiber needed to be applied.

On March 10th, 2005, the preparation of the pipe for the carbon fiber installation was finalized, and the carbon fiber installation started. First, the prime coating of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was applied. Before the application of the prime coat, the mixture was confirmed to be at 4 parts of the resin to 1 part of the hardener. After one hour, the epoxy bonding agent was applied to the concrete surface, and the spring lines and first layer of fiber was applied. During the installation, the overlaps of the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction, and the wrap orientation and alignment with the pipe axis were checked. While the fiber was being installed, any bubbles or wrinkles that could be seen were worked out of the fiber. During the application, the saturation mixture of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was observed at 4 to 1, respectively, and the saturation of the carbon fiber was verified at 1 quart per 3 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked

On March 12th, 2005, the carbon fiber installation continued. First, the second layer of carbon fiber was applied. During the installation, the overlaps of the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction, and the wrap orientation and alignment with the pipe axis were checked. While the fiber was being installed, any bubbles or wrinkles that could be seen were fixed. During the installation, the saturation mixture of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was verified at 4 to 1, respectively, and the saturation of the carbon fiber was inspected and found to be at 1 quart per 3 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked

On March 14th, 2005, the carbon fiber application was completed. First, the third layer of carbon fiber and the termination hoops were applied. During the installation, the overlaps of the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction, and the wrap orientation and alignment with the pipe axis were checked. While the fiber was being laid, any bubbles or wrinkles that could be seen were repaired. During the installation, the saturation mixture of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was confirmed to be at 4 to 1, respectively, and the saturation of the carbon fiber was observed to be at 1 quart per 3 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked.

On March 19th, 2005, several tasks were performed to prepare the pipe for the final coat of epoxy bonding agent. First, the proper mixing of epoxy bonding agent using

Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was verified. Then, the epoxy bonding agent was applied to the edges of the fiber and joints.

On March 20th, 2005, the final coating of the epoxy bonding agent was sprayed on the entire pipe. During the application, the proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was inspected.

On March 21st, 2005, the pipe was checked for voids, and the voids were injected using Injection Resin PRI 2000-1-J-A & B. Then, the ridges, lines and splatters in the Cabosil were grinded smooth. After four to six hours, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and verified at a 3 to 1 ratio, respectively. Then, the first coat of the ARC was sprayed on the entire spool.

On March 22rd, 2005, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and observed to be at a 3 to 1 ratio, respectively. Then, the second coat of the ARC was applied to the spool.

On March 23rd, 2005, the final inspection was accomplished on the pipe.

2.3.15. Pipe Spool No. 60

Pipe size = 84 inches

Pipe length = 19.92 feet

On March 9th, 2005, there were several tasks that were performed to prepare the pipe for the carbon fiber application. First, the roughness of the sand blasted, concrete surface was verified at ±1/16" amplitude, and the excess water and debris were removed. Next, the spool was crack mapped, and the cracks were confirmed to be clean. While crack mapping, major spiral and longitudinal cracks were found in the pipe (See Appendix A). Due to the amount and extent of cracks in the pipe, another layer of fiber needed to be applied.

On March 10th, 2005, the cracks were sealed with Injection Resin PRI 2000-1-J-A & B.

On March 14th, 2005, the preparation of the pipe for the carbon fiber installation was finalized. First, the prime coating of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was applied. Before the application of the prime coat, the mixture was inspected and found to be at 4 parts of the resin to 1 part of the hardener.

On March 15th, 2005, the carbon fiber installation was completed. First, the epoxy bonding agent was applied to the concrete surface, and the three layers of fiber were applied. During the application, the overlaps of the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction, and the wrap orientation and alignment with the pipe axis were checked. While the fiber was being applied, any bubbles or wrinkles that could be seen were repaired. During the installation, the saturation mixture of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was observed to be at 4 to 1, respectively, and the saturation of the carbon fiber was confirmed to be at 1 quart per 3 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked.

On March 19th, 2005, several tasks were performed to prepare the pipe for the final coat of epoxy bonding agent. First, the proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was inspected. Then, the epoxy bonding agent was applied to the edges of the fiber and joints.

On March 20th, 2005, the final coating of the epoxy bonding agent was sprayed on the entire pipe. During the application, the proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was observed.

On March 21st, 2005, the pipe was checked for voids, and the voids were injected using Injection Resin PRI 2000-1-J-A & B. At this time, any ridges, splatters, or lines seen in the Cabosil were grinded until smooth. Then, after four to six hours, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and confirmed to be at a 3 to 1 ratio, respectively. Then, the first coat of the ARC was sprayed on the entire spool.

On March 22rd, 2005, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and verified at a 3 to 1 ratio, respectively. Then, the second coat of the ARC was applied to the spool.

On March 23rd, 2005, the final inspection was performed on the pipe.

2.3.16. Pipe Spool No. 61

Pipe size = 84 inches

Pipe length = 19.89 feet

On March 9th, 2005, there were several tasks that were accomplished to prepare the pipe for the carbon fiber installation. First, the roughness of the sand blasted, concrete surface was observed to be at ±1/16" amplitude and the excess water and debris were removed. Next, the spool was crack mapped, and the cracks were confirmed to be clean. While crack mapping, major spiral and longitudinal cracks were found in the pipe (See Appendix A). Then, the cracks were sealed with Injection Resin PRI 2000-1-J-A & B. Due to the extensive amount of cracks in the pipe, another layer of fiber needed to be applied.

On March 14th, 2005, the preparation of the pipe for the carbon fiber application was finalized, and the carbon fiber installation started. First, the prime coating of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was applied. Before the application of the prime coat, the mixture was verified at 4 parts of the resin to 1 part of the hardener. After one hour, the epoxy bonding agent was applied to the concrete surface, and the first layer of fiber was applied. During the installation, the overlaps of the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction, and the wrap orientation and alignment with the pipe axis were checked. While the fiber was being installed, any bubbles or wrinkles that could be seen were fixed. During the installation, the saturation mixture of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was inspected and found to be at 4 to 1, respectively, and the saturation of the carbon fiber was observed to be at 1 quart per 3 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked

On March 17th, 2005, the carbon fiber application continued. First, the second layer of carbon fiber was applied. During the installation, the overlaps of the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction, and the wrap orientation and alignment with the pipe axis were checked. While the fiber was being laid, any bubbles or wrinkles that could be seen were repaired. During the installation, the saturation mixture of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was confirmed to be at 4 to 1, respectively, and the saturation of the carbon fiber was verified at 1 quart per 3 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked

On March 18th, 2005, the carbon fiber application was completed. First, the third layer of carbon fiber and the termination hoops were applied. During the installation, the overlaps of the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction, and the wrap orientation and alignment with the pipe axis were checked. While the fiber was being installed, any bubbles or wrinkles that could be seen were repaired. During the installation, the saturation mixture of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was observed to be at 4 to 1, respectively, and the saturation of the carbon fiber was inspected and found to be at 1 quart per 3 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked.

On March 19th, 2005, several tasks were performed to prepare the pipe for the final coat of epoxy bonding agent. First, the proper mixing of epoxy bonding agent using

Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was verified. Then, the epoxy bonding agent was applied to the edges of the fiber and joints.

On March 20th, 2005, the final coating of the epoxy bonding agent was sprayed on the entire pipe. During the application, the proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was observed.

On March 21st, 2005, the pipe was checked for voids, and the voids were injected using Injection Resin PRI 2000-1-J-A & B. Then, any ridges, lines, or splatter found in the Cabosil were grinded until smooth. Next, after four to six hours, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and confirmed to be at a 3 to 1 ratio, respectively. Finally, the first coat of the ARC was sprayed on the entire spool.

On March 22rd, 2005, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and verified at a 3 to 1 ratio, respectively. Then, the second coat of the ARC was applied to the spool.

On March 23rd, 2005, the final inspection was performed on the pipe.

2.4. Access Manhole No. 1A

2.4.1. Pipe Spool No. 129

Pipe size = 114 inches

Pipe length = 15.97 feet

On March 16th, 2005, there were several tasks that were accomplished to prepare the pipe for the carbon fiber application. First, the roughness of the sand blasted, concrete surface was inspected and found to be at ±1/16" amplitude and the excess water and debris were removed. Next, the spool was crack mapped, and the cracks were confirmed to be clean. While crack mapping, two spiral, one hoop and longitudinal cracks were found in the pipe (See Appendix A). All four of these cracks needed patching. Then, the cracks were sealed with Injection Resin PRI 2000-1-J-A & B. Finally, the prime coating of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was applied. Before the application of the prime coat, the mixture was observed to be at 4 parts of the resin to 1 part of the hardener. After one hour, the epoxy bonding agent was applied to the concrete surface, and the spring lines, one 5'-0" patch, and three 31'-9" patches were applied. Next, the two layers of fiber and the termination hoops were applied. During the installation, the overlaps of the fabric were checked at 9" in the hoop direction and 2" in the longitudinal direction, and the wrap orientation and alignment with the pipe axis were checked. While the fiber was being applied, any bubbles or wrinkles that could be seen were worked out of the fiber. During the installation, the saturation mixture of Saturating Resin PRI 2000-3-R-A & 2000-5-HR-B was confirmed to be at 4 to 1, respectively, and the saturation of the carbon fiber was verified at 1 quart per 3 linear feet. Also, proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was checked

On March 19th, 2005, several tasks were performed to prepare the pipe for the final coat of epoxy bonding agent. First, the proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was inspected. Then, the epoxy bonding agent was applied to the edges of the fiber and joints.

On March 20th, 2005, the final coating of the epoxy bonding agent was sprayed on the entire pipe. During the application, the proper mixing of epoxy bonding agent using Resin PRI 2000-3-R-A & 2000-5-HR-B with Cabosil was observed.

On March 21st, 2005, the pipe was checked for voids, and the voids were injected using Injection Resin PRI 2000-1-J-A & B. During this time, any ridges, lines, or splatters in the Cabosil were grinded until smooth. After four to six hours, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and confirmed to be at a 3 to 1 ratio, respectively. Finally, the first coat of the ARC was sprayed on the entire spool.

On March 22nd, 2005, the PRI 2001C-R-A and PRI 2001C-H-B for the Abrasive Resistive Coating (ARC) were mixed for two minutes and verified at a 3 to 1 ratio, respectively. Then, the second coat of the ARC was applied to the spool.

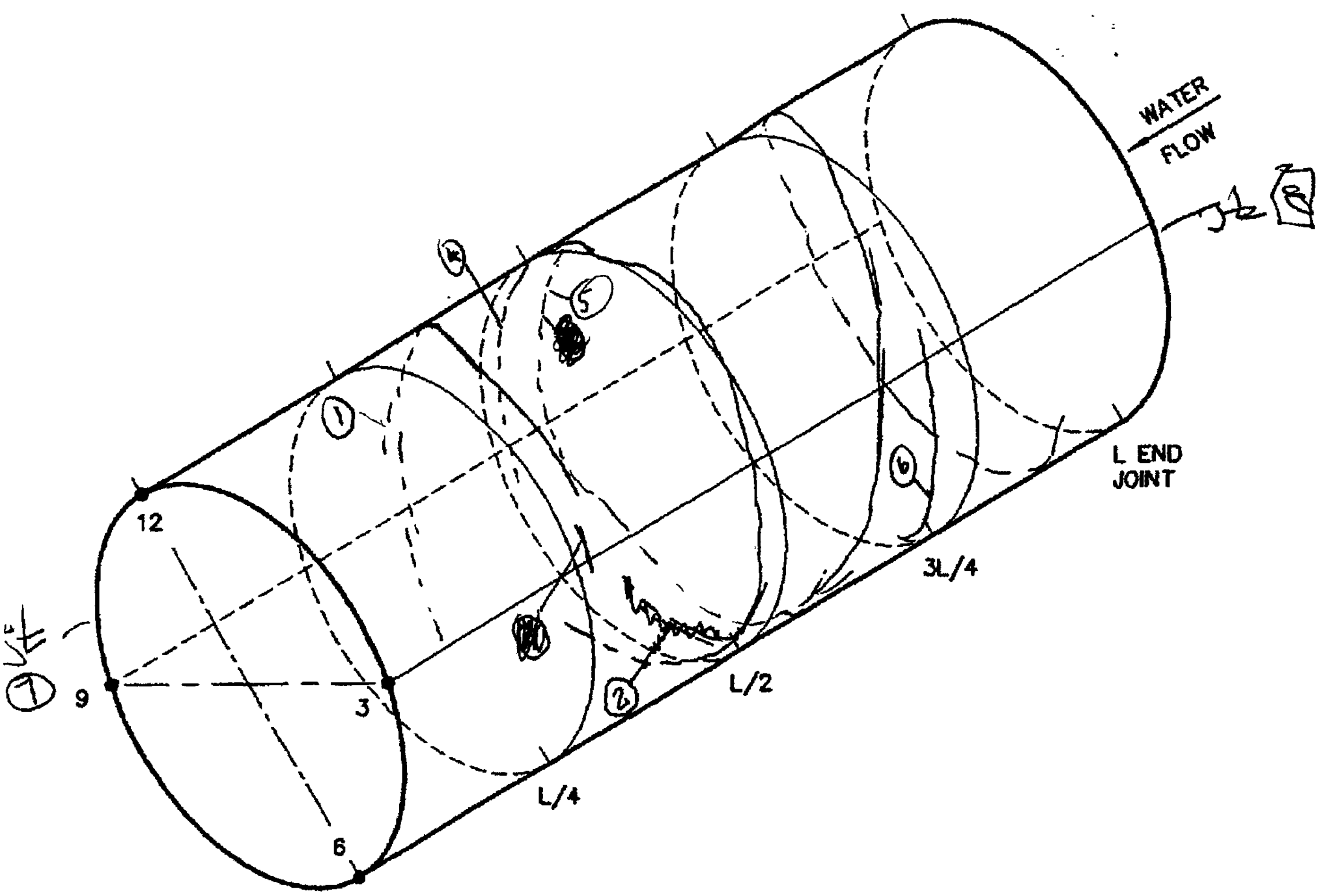
On March 23rd, 2005, the final inspection was performed on the pipe.

3. Summary

In March of 2005, there were thirty-eight sections in Unit 1 of Intermountain Power Generation Station that were repaired with the quality installation of carbon fiber on the interior surface. The completion of work involved the application of the composite system by Gateway, the quality assurance and design of the carbon fiber installation by KPFF Consulting Engineers, and the overseeing and coordination performed by Intermountain Power Service Corporation. The carbon fiber installation had four stages: preparation of the pipe, the fiber installation, the Cabosil application, and the Abrasive Resistive Coating application.

There were several key factors which contributed to a successful, early completion of the project. Gateway's expertise in the application of coatings and cooperation helped expedite the project. Their grit blasting, the spraying of the Cabosil, and speed and skill in the carbon fiber installation saved manpower and six to eight days on the schedule. Gateway crews listened to KPFF Consulting Engineer's recommendations which made the project go smoothly. Intermountain Power Service Corporation's behind the scenes work and key role in the coordination of activities of IPSC, Gateway, and KPFF Consulting Engineers helped lead the way for a successful completion of the project.

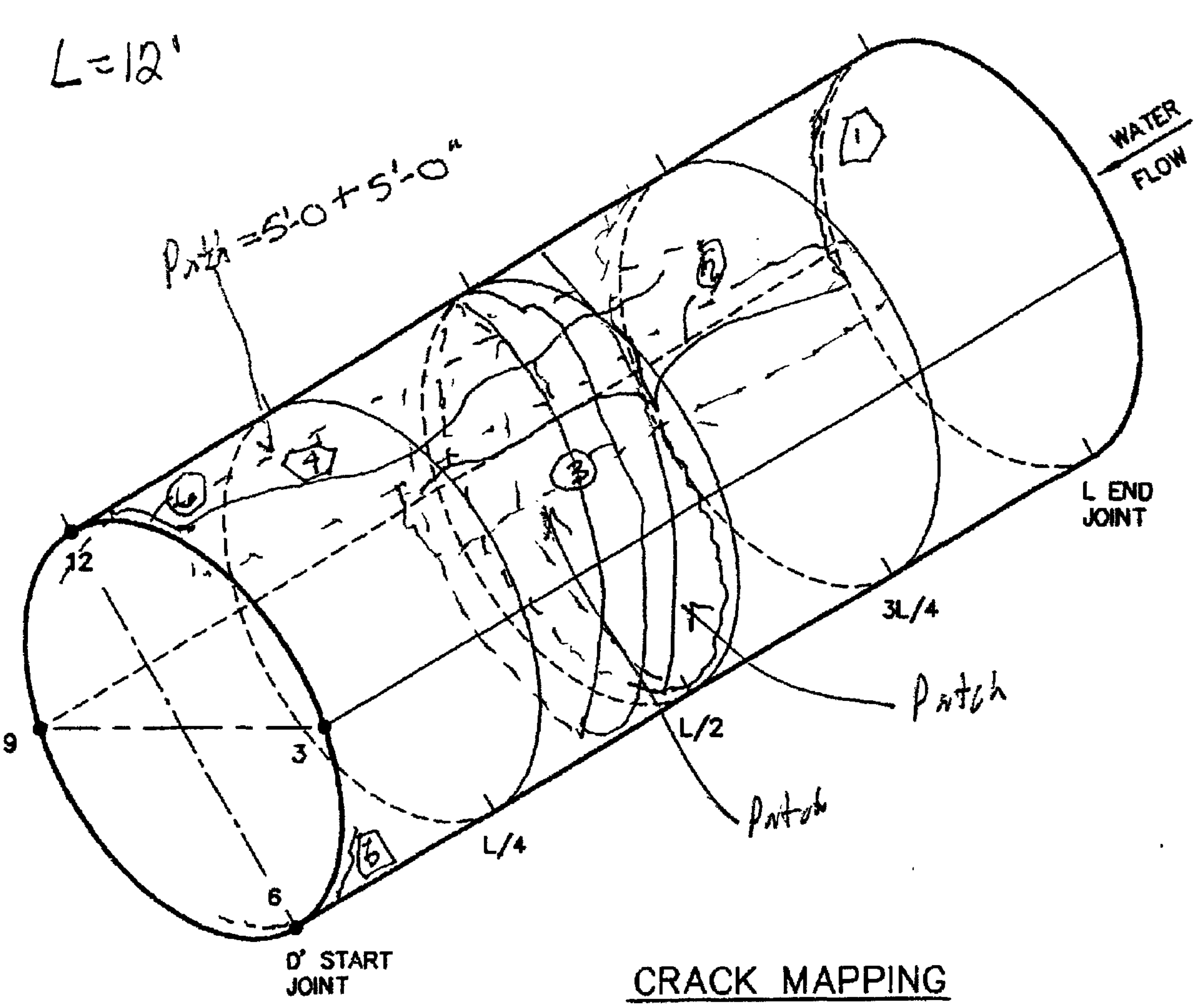
4. Appendix A



CRACK MAPPING

SPOOL NO. 428 MANHOLE NO. 2b

CRACK NO.	LOCATION	DESCRIPTION	REMARKS
1	start 8⁰⁰ to 3⁰⁰ L/4 - L/2	spiralcrack	L = [illegible]. 13-0
2	6⁰⁰ to 8⁰⁰ L/4 - L/2	spiral crack	L = 24'-0"
4 . 5	12⁰⁰ 5⁰⁰ L/2 - 3L/4	spiral crack 2X	L = 36-0
6	6⁰⁰ 3⁰⁰	Hoopcrack	L = 10-6
7	jt crack - 7-3 oclock, 6 oclock	jt crack	L = 15'2" L = 2'-0"
8	jt crack all the way around	jt crack	"24'-0"



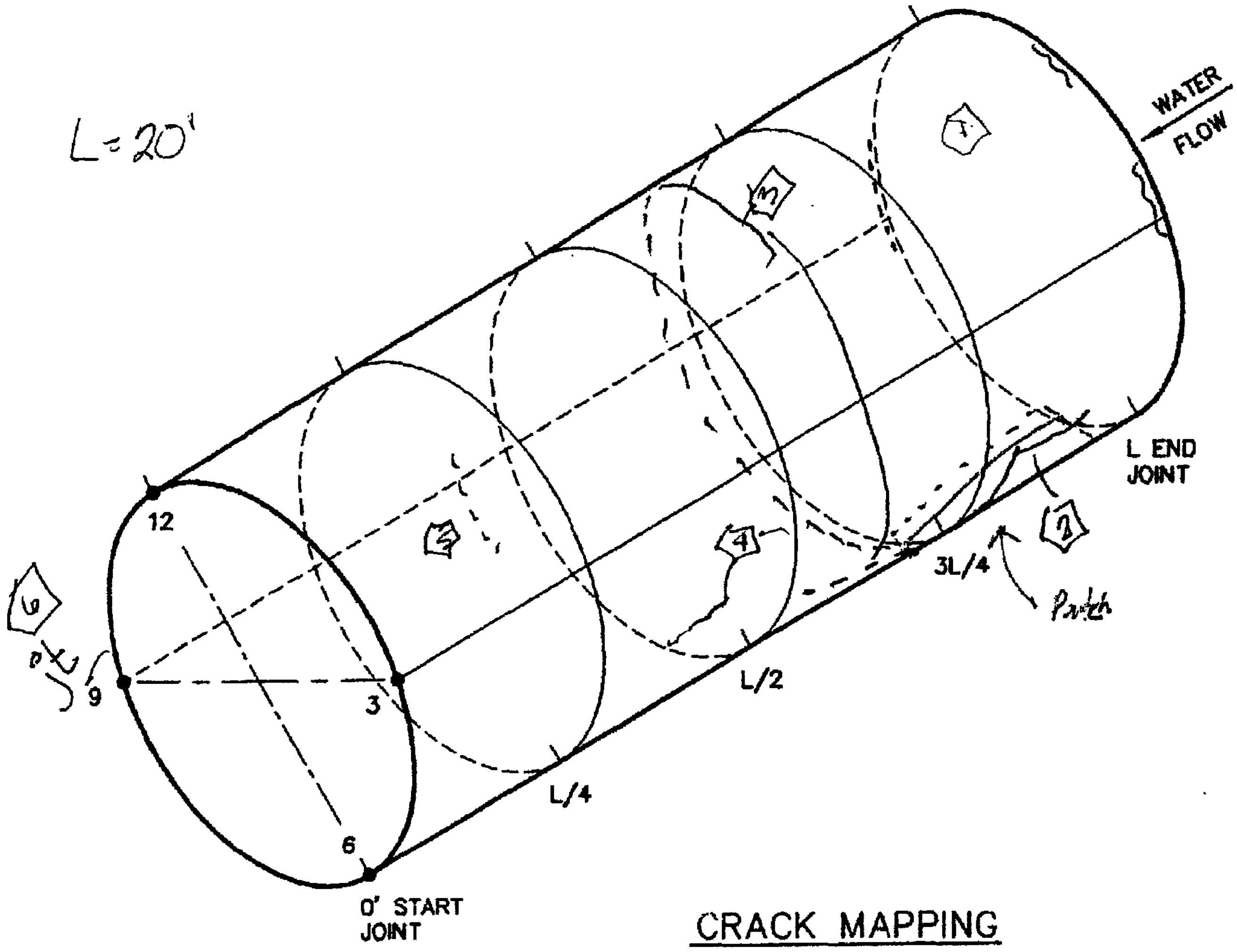
CRACK MAPPING

SPOOL NO. 535 MANHOLE NO. 2b

CRACK NO.	LOCATION	DESCRIPTION	REMARKS
1	9 o'clock to 12 o'clock	jt crack	L = 7-0
2	from L/2 to L @ 9 o'clock	longitudinal crack-mc	= Patch = 9-0
3	3 o'clock all the way around to 6 o'clock Between L/4 + L/2	spiral crack	L = 27-10 Patches = 8-0 + 21-0
4	1 o'clock to 11 o'clock from L/2 to 0	longitudinal-mc crack off of 3	10-0 = L PATCH = (2) 5-0 +
5	7 o'clock to 5 o'clock @ start joint	jt crack/hoop-mc crack	L = 7-6"
6	10 o'clock to 12 o'clock	hoop crack - mc	L = 3'-0"

IP12_003631

L=20'

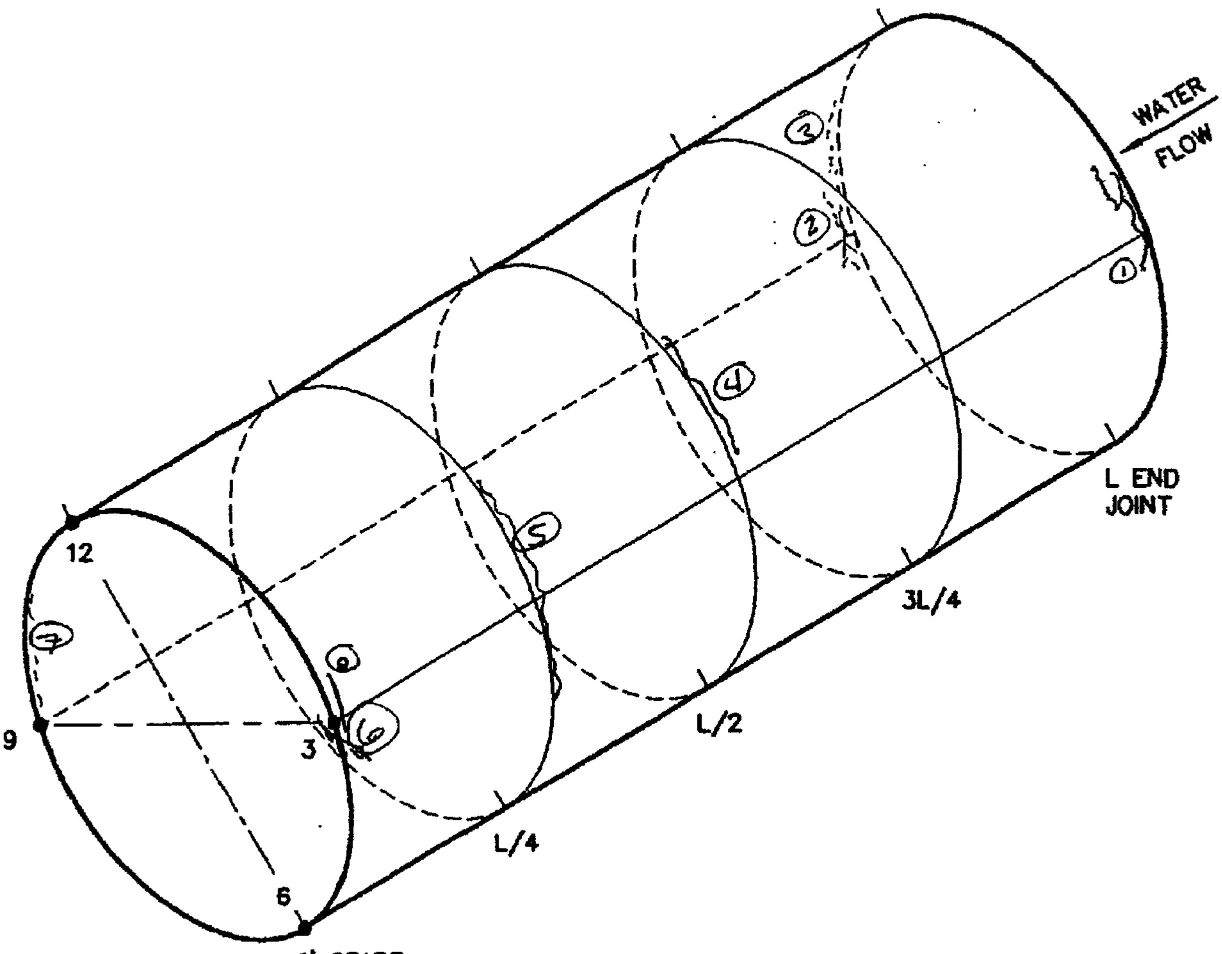


CRACK MAPPING

SPOOL NO. 533 MANHOLE NO. 2b

CRACK NO.	LOCATION	DESCRIPTION	REMARKS
1	9 oclock - 10 oclock, 12-1 oclock, 3 oclock	jt crack	L = 24-0
2	starts 2' from L and goes to 2' from L/2 @ 5-6 oclock	6' long - longitudinal	L=5-6 PATCH=7-6
3	6 oclock to 5 oclock - near 3L/4 to L/2	spiral crack	L=19-0
4	1' - between L/2 + L/4 @ 5 oclock	long. crack	L = 1'-6"
5	@ 9 oclock	hoop crack	L = 1'-6"
6	jt repair -	- epoxy coating - crack	24-0 = L

7	start end 6:00	Long	patch	(16'-0")
8	start end ~~7:00~~ 7:00-2:00	Long micro	patch	(16'-0")
9	34/4	3/4 Hoop		
10	34/4 9:00	~~15"~~ micro ~~[illegible]~~ 15"		
11	@ endjoint 1:00-10:00	joint crack 1/2 hoop		
12	@ endjoint 9:00	joint crack 10"		
13	@ endjoint 3:00-7:00	joint crack 1/2 hoop 144"		



CRACK MAPPING

16' long

SPOOL NO. 480 MANHOLE NO. 2b

CRACK NO.	LOCATION	DESCRIPTION	REMARKS
1	3 o'clock both 8" long	microcrack	8"
2	9 o'clock 16" long	joint crack	16"
3	10:30 at top 12" long	MC	12"
4	28" long starting @ ~~245~~ 245 L/2	MC	28"
5	37" long starting @ 330 L/4	MC	39"
6	7" long starting @ 37 L/4	MC	7"

Total Crack L = 10'-1

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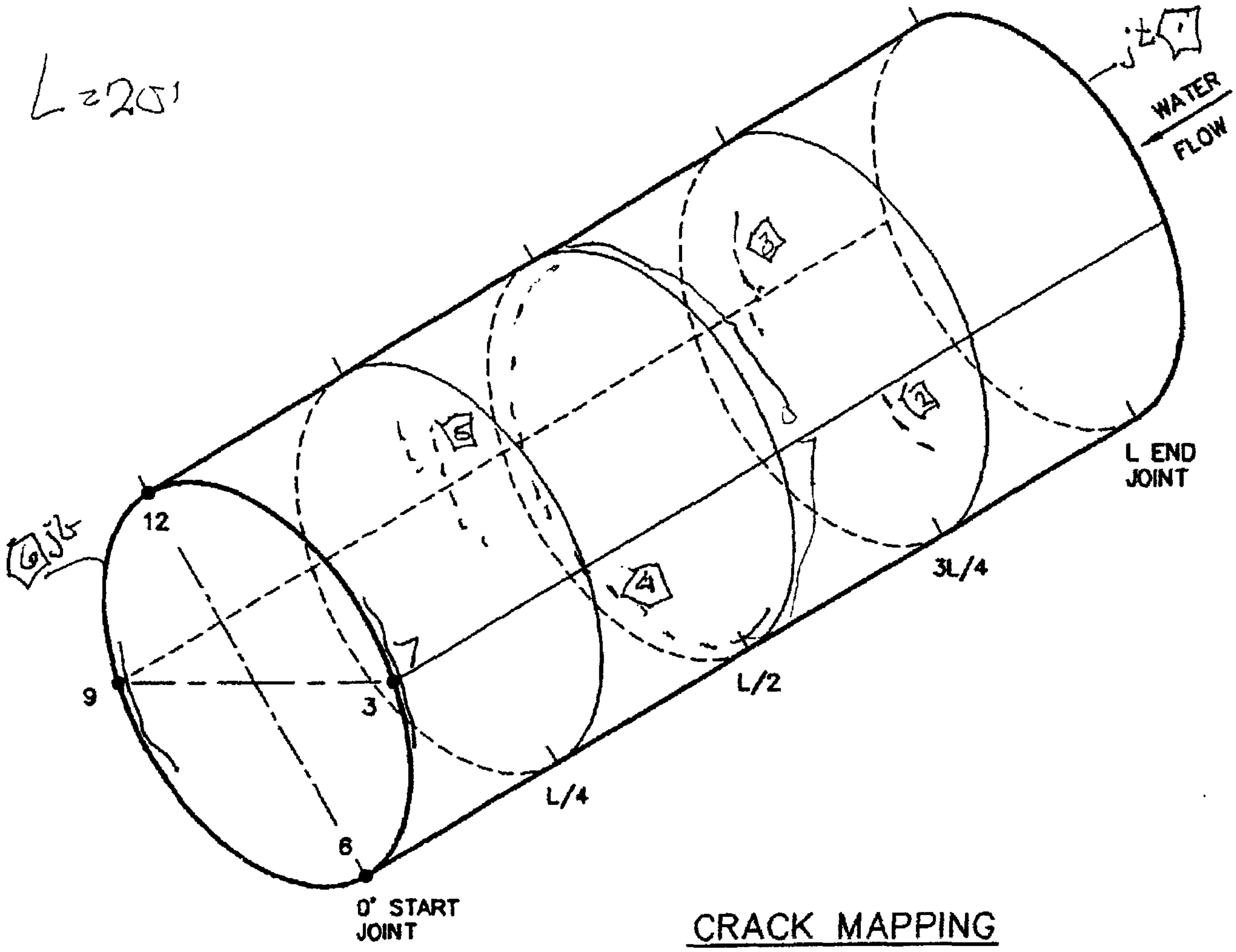
8 11½" long starting @ 3:00 jt crack 11½"

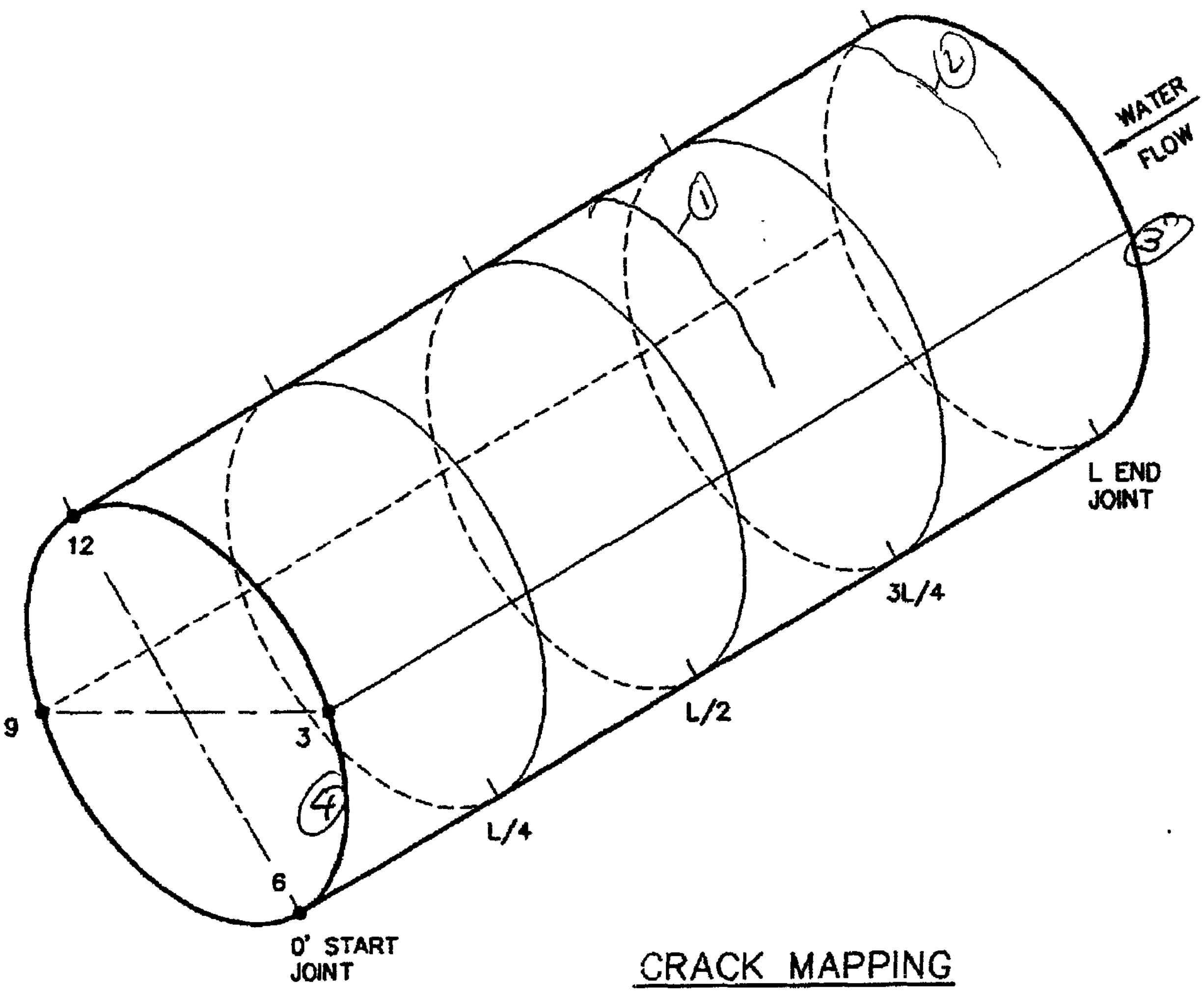
L=20'



CRACK MAPPING

SPOOL NO. 430 MANHOLE NO. 2b

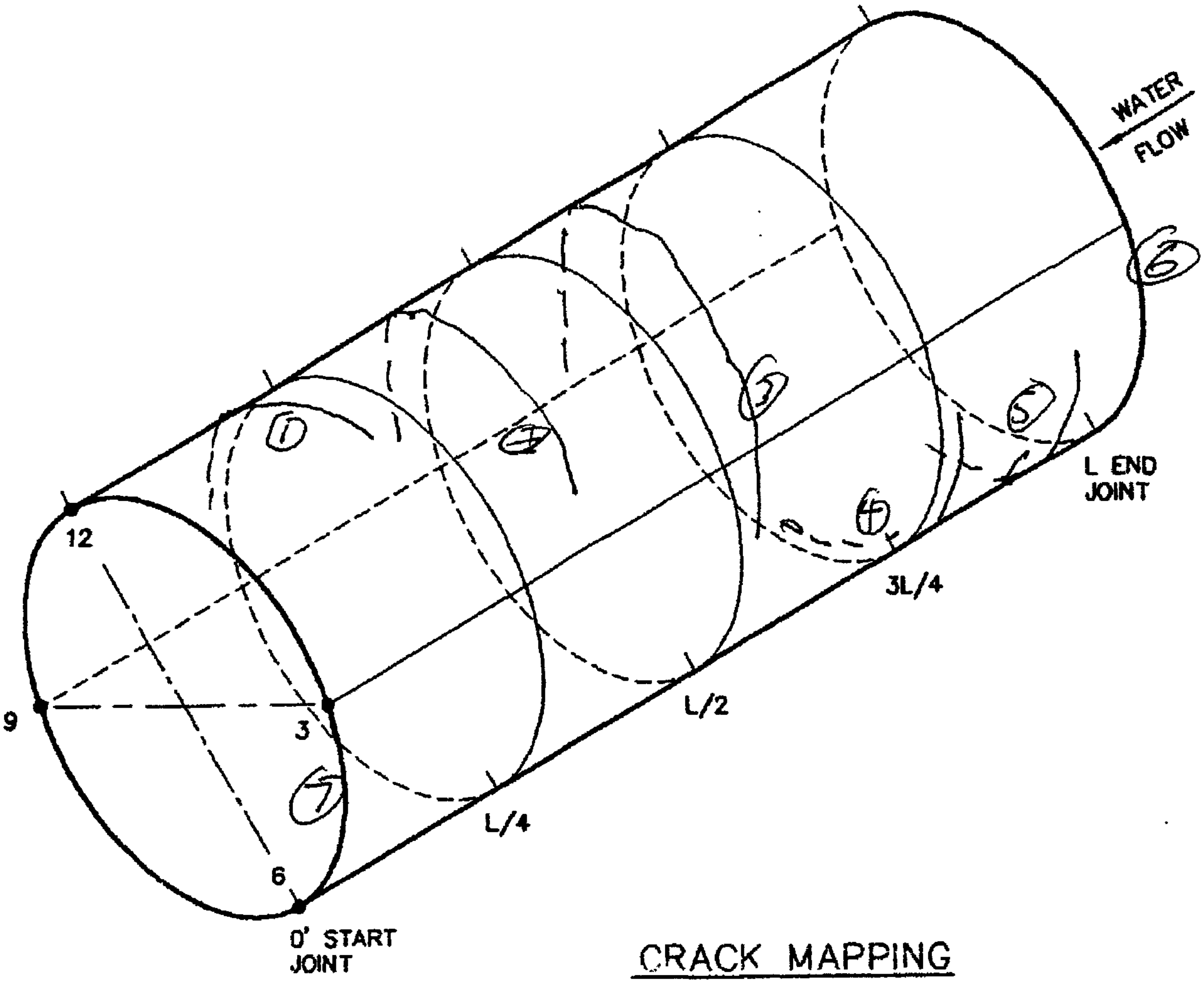
CRACK NO.	LOCATION	DESCRIPTION	REMARKS
1	12oclock - 12oclock	jt crack	22'-0"
2	7oclock - 2.5' long	hoop crack & mo	16"
3	10oclock - 1.5' long	hoop crack - mo	10"
4	~~9~~ 12 oclock - ~~3~~ 12 oclock	hoop crack	~~[illegible]~~ 24'-0"
5	9oclock	hoop crack - mo	2-6
6	jt 12-12oclock	jt crack	6"
7		at joint	~~21'-0"~~ 22'-0"



CRACK MAPPING

SPOOL NO. 532A MANHOLE NO. 26

CRACK NO.	LOCATION	DESCRIPTION	REMARKS
1	12^{00} 3^{00} L/2 – 3L/4	MICRO crack Hope crack	3'6"
2	12^{00} 3^{00} 3L/4 – L END	Micro, hope crack	4'4"
3	JOINT		22'-0"
4	JOINT		22'-0"



CRACK MAPPING

SPOOL NO. 339 MANHOLE NO. 2b

CRACK NO.	LOCATION	DESCRIPTION	REMARKS
1	L/4	11-1	3'-0"
2	3L/8	11-3	6'-0"
3	L/2	9-5	13'-0"
4	3L/4	4-7	moisture coming thru 5'-0"
5	7L/8	4-7	moisture coming thru 3'-0"
6	JOINT		22'-0"
7	JOINT		22'-0"

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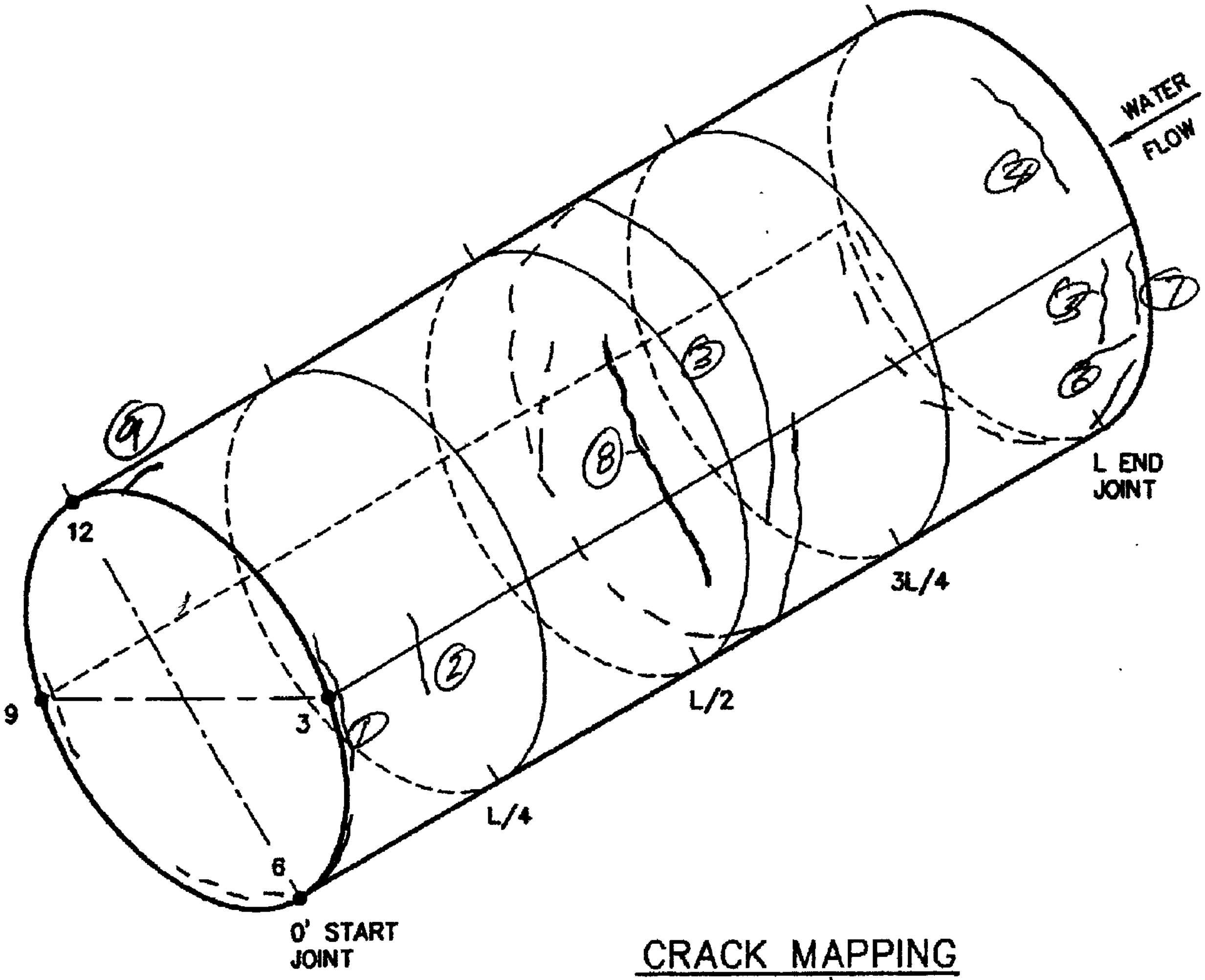
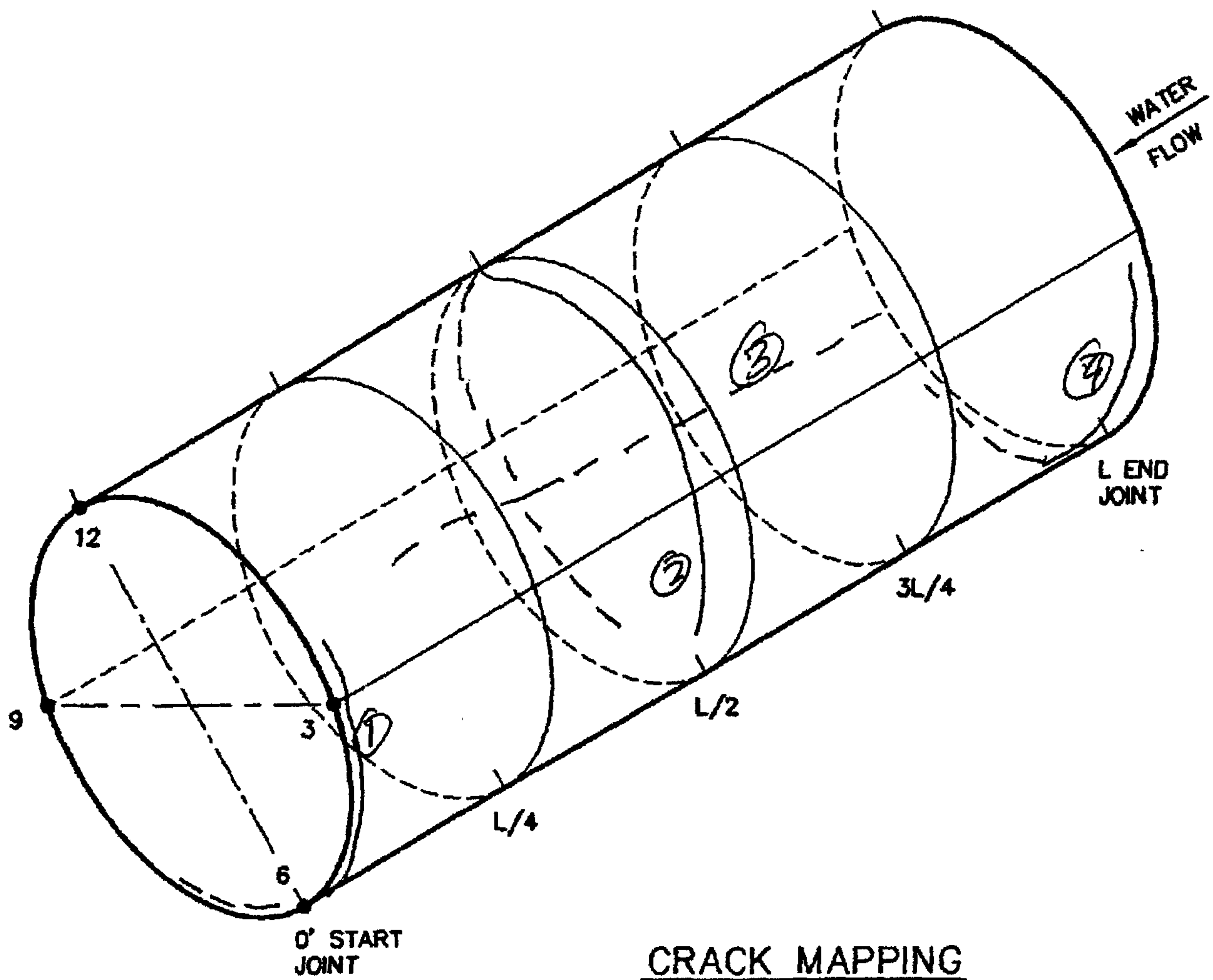


CRACK MAPPING
800" = 66.7'

SPOOL NO.	516	MANHOLE NO.	24 TEAM B

CRACK NO.	LOCATION	DESCRIPTION	REMARKS
1	AT JOINT	16'0" 3-9	
2	Micro crack	1'0" 3	
3	Hoop crack	35'0" 12-12	
4 5	Micro crack Micro Crack	3'0" 1-2 2'6" 3-4	
6 7	Short Longitudinal AT JOINT	1'0" 4 16'0 3-9	
8 9	HOOP CRACK 1/4" WIDE CRACK	5'-0" 3-5 6" 12	 FILLED WITH SOFT EPOXY

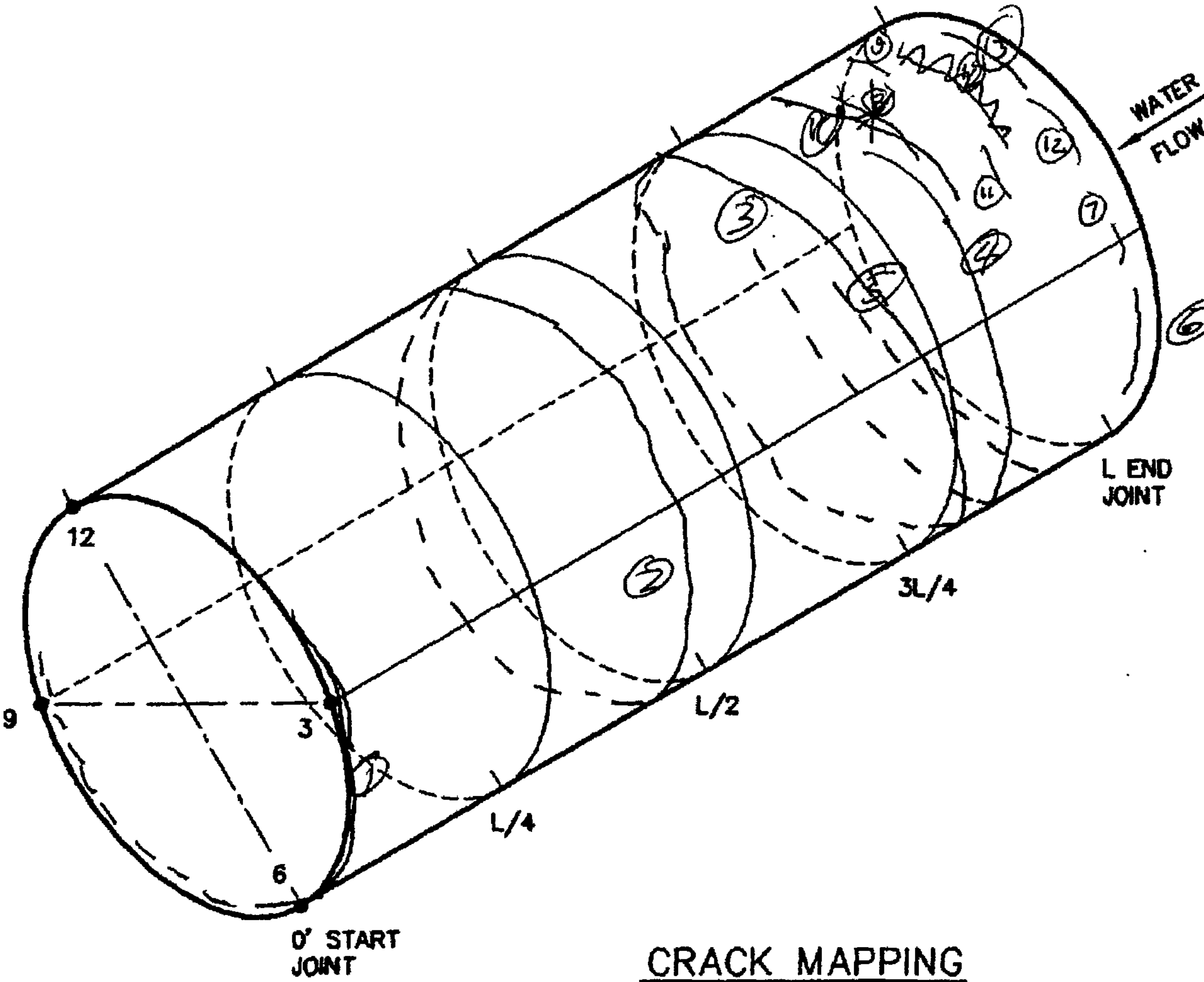


CRACK MAPPING

63' = 756"

SPOOL NO. 505 MANHOLE NO. 2A TEAM B

CRACK NO.	LOCATION	DESCRIPTION	REMARKS
1	At Joint	15' 2-7	INJECTION
2	Hoop Crack	29' 6- 12-5	
3	longitudinal crack	10' 7	
4	At joint	9' 5-7	



CRACK MAPPING

130'=1560"

SPOOL NO.	408	MANHOLE NO.	2A TEAM B

CRACK NO.	LOCATION	DESCRIPTION	REMARKS
1	AB Joint	19' 2-9	INJECTION
2	Hoop Crack	32' 12-12	
3	Hoop Crack	32' 12-12	
4	Micro Crack	19' 12-9	
5	Micro Crack	8' 6-8	
6	At Joint	3' 5-6	
7	MICROCRACK	2' 3	over

IP12_003641

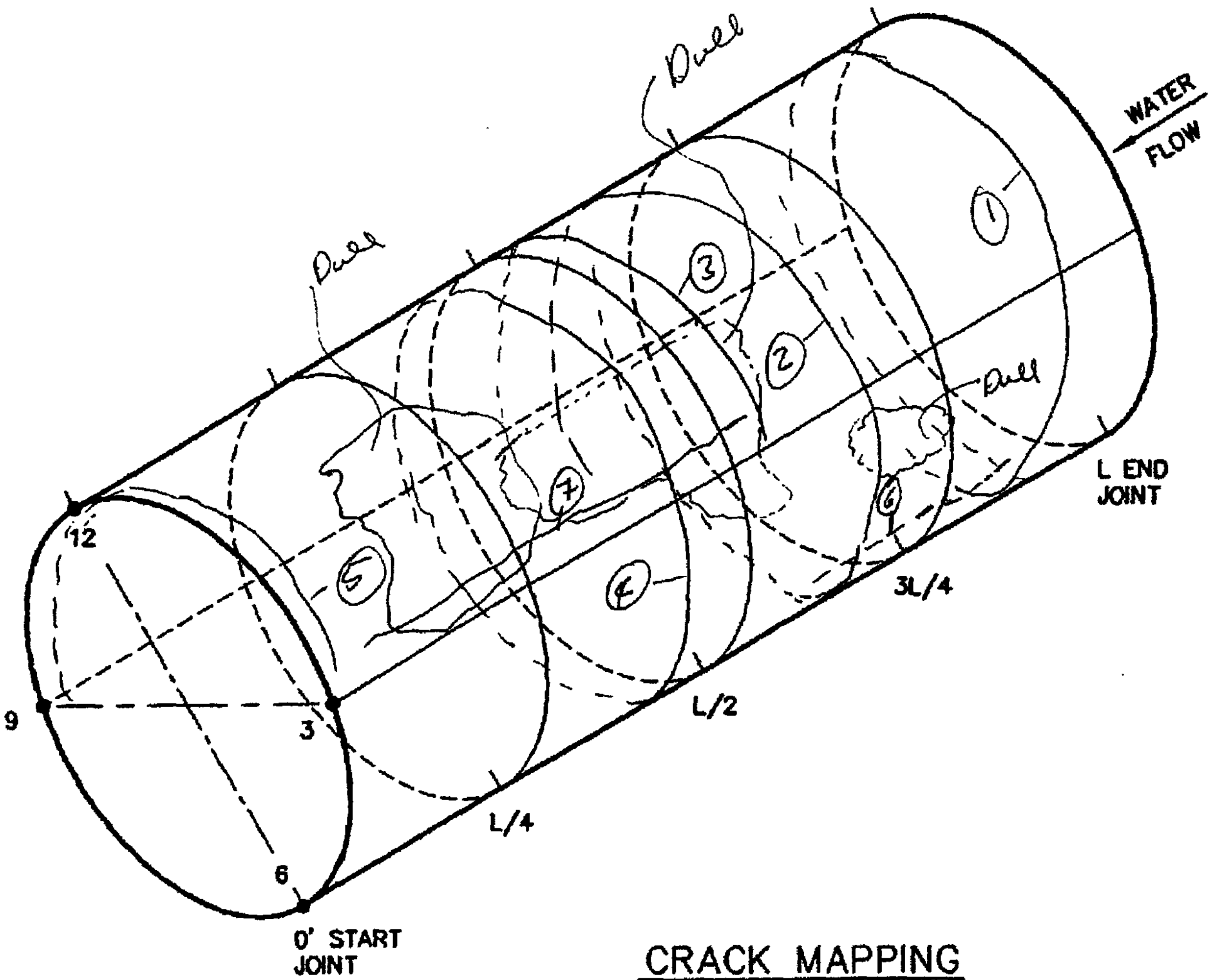
~~8~~
9
10
11
12
13

MICROCRACK

11-12
8' 11-2
1' 10-11
2' 10-11
4' 11-12M

INJECTION

IP12_003642

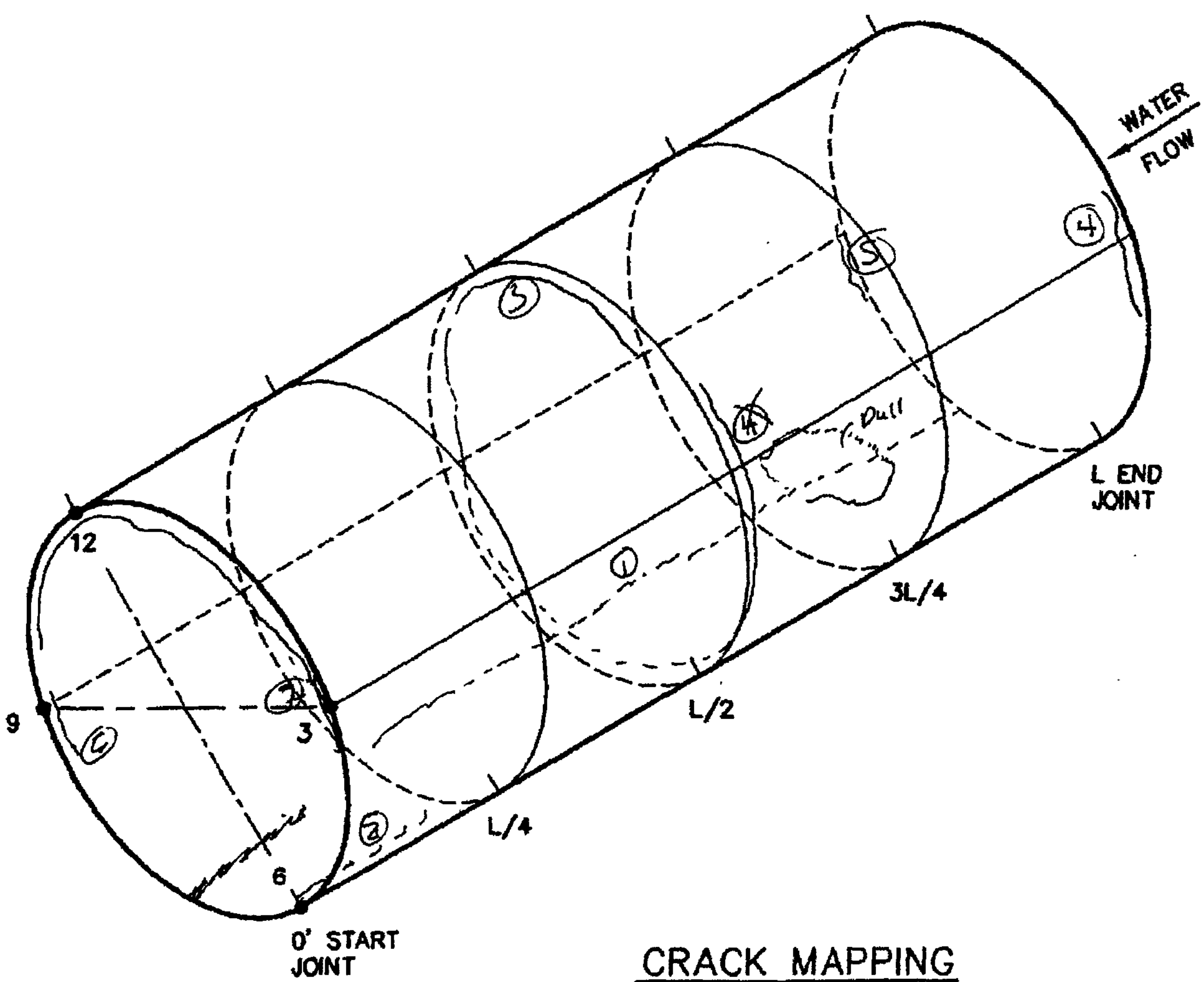


CRACK MAPPING

136' = 1632"

SPOOL NO. ~~[illegible]~~ 319 MANHOLE NO. TEAM C

CRACK NO.	LOCATION	DESCRIPTION	REMARKS
1	3L/4 - END 6 o'clock to 7 o'clock	spiral crack	13 h INJECTION
2	L/2 - 3L/4 11 o'clock to 9 o'clock	spiral crack	↓
3	L/2 - 3L/4 9 o'clock to 3 o'clock	Hoop crack	PATCH
4	L/4 - L/2 9 o'clock to 9 o'clock	spiral crack	INJECTION
5	0'start - L/4 3 o'clock to 9 o'clock	joint crack	
6	LEND to 3L/4	length crack	7 feet
7	start to mid L/2		7 feet



CRACK MAPPING

59'

SPOOL NO. 499 MANHOLE NO. 2A TEAM C

CRACK NO.	LOCATION	DESCRIPTION	REMARKS
1	645 L/4 TO joint	11' patch needed horiz. crack	PATCH
2	600 beg. of joint (0')	5'-4" patch needed horiz crack	PATCH
3	L/2	~~hoop crack~~ circumference spiral micro crack	
~~4~~ 4	end joint 27"	~~micro crack~~ ~~3½'~~	
5	end joint 16"		
6 7	start joint 34" " " 22"		

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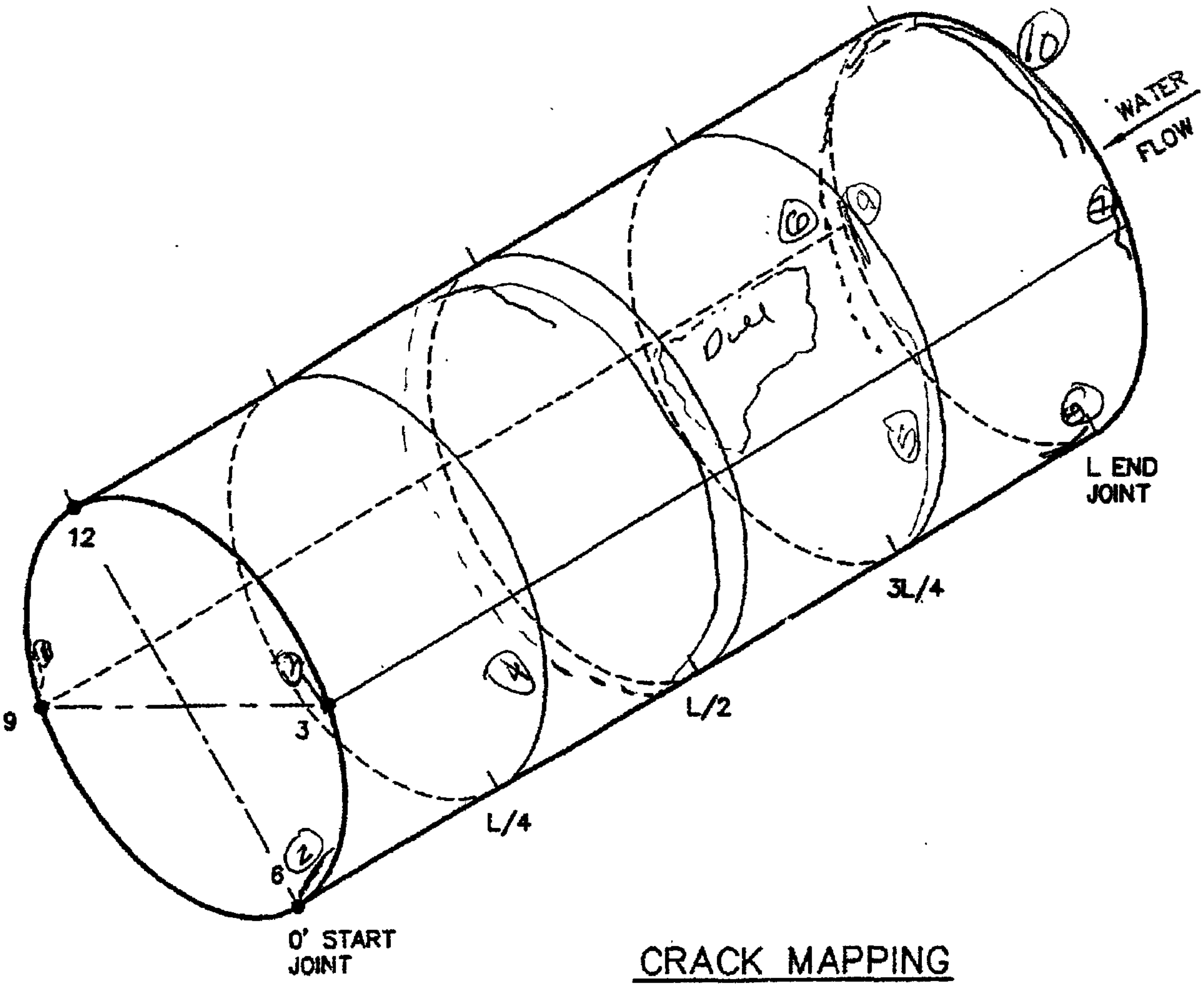


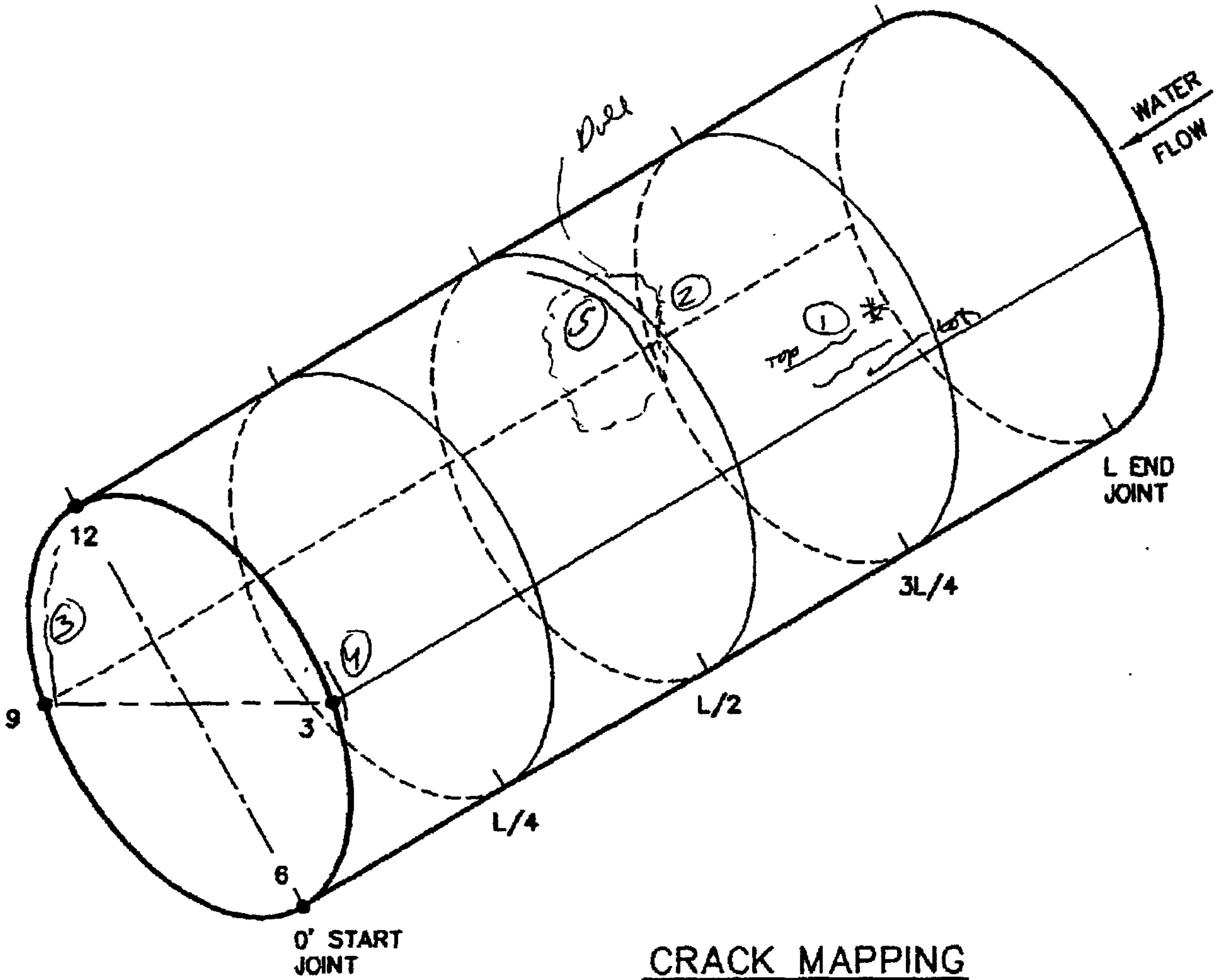
CRACK MAPPING

42'

SPOOL NO. 49 MANHOLE NO. 2A TEAM: C

CRACK NO.	LOCATION	DESCRIPTION	REMARKS
1	@ Start joint 9:00	Joint Crack 17.5"	
2	@ Start joint 5:30 starts @ joint	long. microcrack 14.5"	
3	@ Start joint 3:00	Joint Crack 12"	
4	L/2 (80" from start) 6:00 - ~~4:00~~ 6:00	hoop crack	
5	69" from end joint 3L/4 5:00 - ~~3~~ 2:00	1/4 hoop 69"	
6	6" from end joint 2:00 - ~~2:00~~ 2:00	58" + 11"	

7	@ end joint 9.00	joint crack 24"
8	@ endjoint ~~6:00~~ 5:00 7:00	joint crack 36"
9	@ end joint 9:00	joint crack 20.5" ≈ 8'
10	@ END JT.	

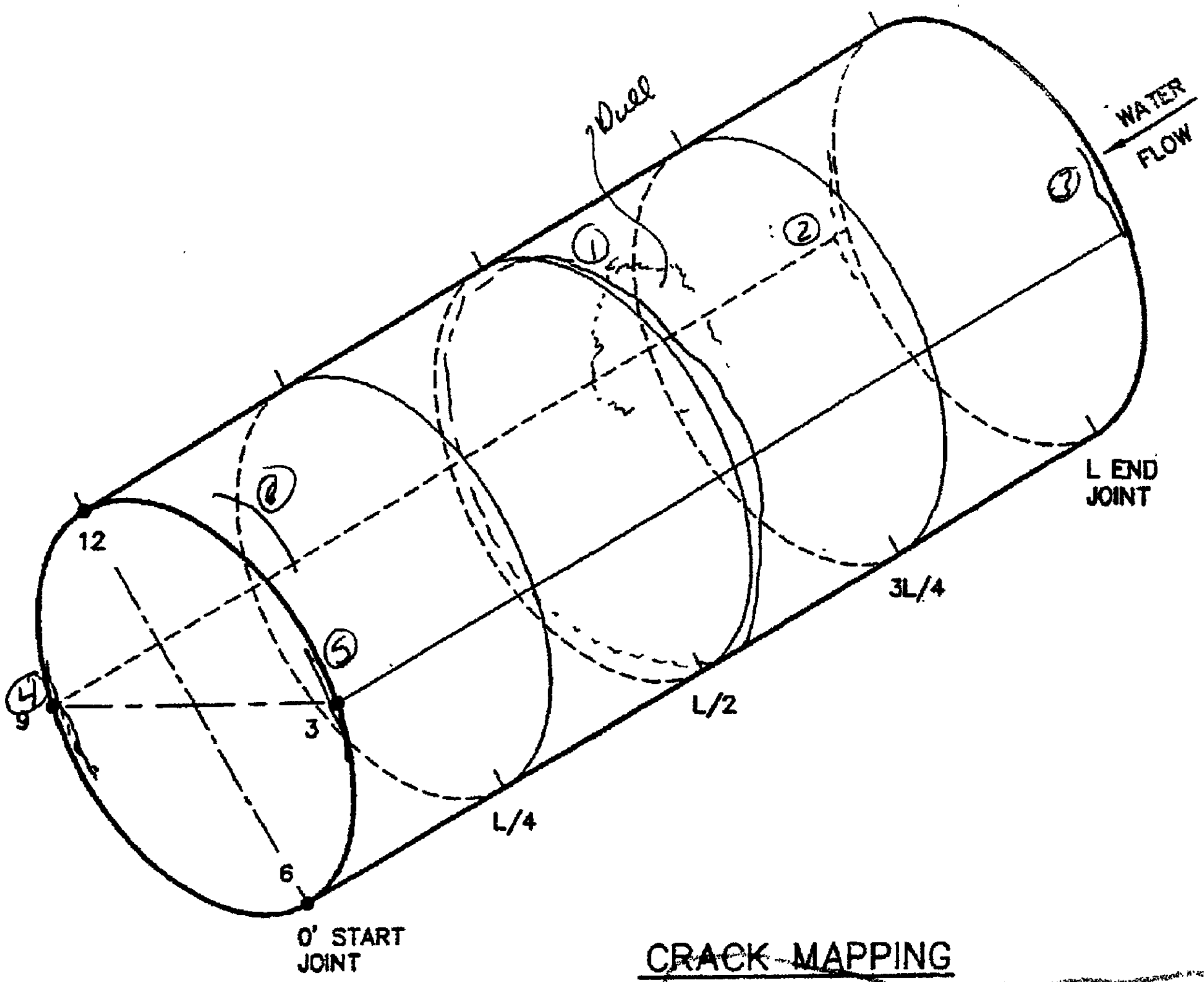


CRACK MAPPING

23'

SPOOL NO. 347 A	MANHOLE NO. 2A	TEAM : C

CRACK NO.	LOCATION	DESCRIPTION	REMARKS
1	@ 3L/4 top: 1'-3" middle: 2'-8" bottom: 3'-7"	micro horiz. cracks	
2	3L/4 1'-7"		
3	9-11 6'	JT. CRACK	
4	2-3 4'	JT. CRACK	
5	1-2 4'	MICROCRACK	



CRACK MAPPING

44' 1 Length = 16'

SPOOL NO. 344A MANHOLE NO. 2A TEAM : C

CRACK NO.	LOCATION	DESCRIPTION	REMARKS
1	L/2	hoop crack microcrack circ.	
2	joint (end) 18"		
3	joint (end) A"		
4	joint (start) 2'-4"		
5	joint (start) 2'		
8	MICRO CRACK	1'-2 3'	

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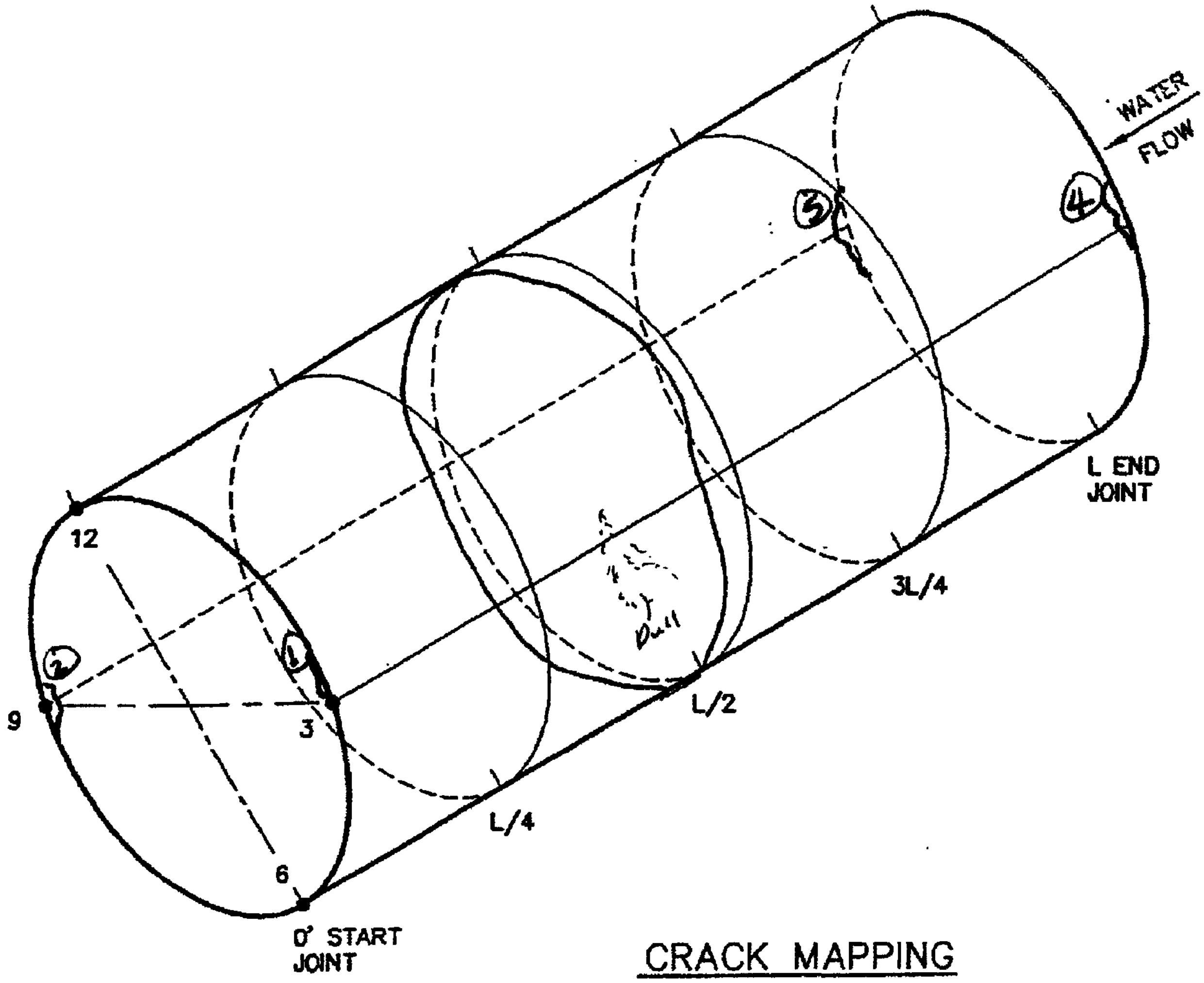
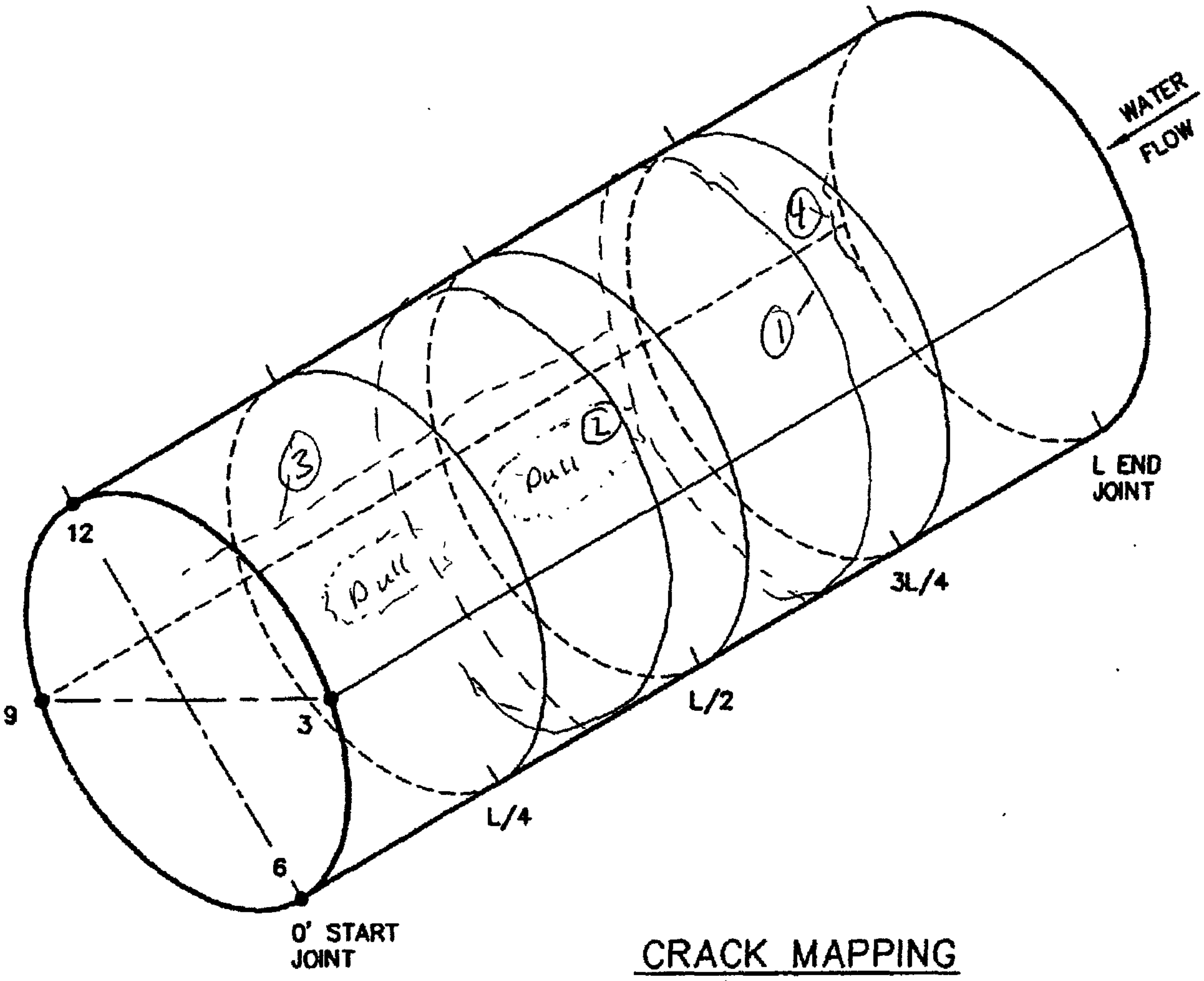


CRACK MAPPING

42.3' = 508"

SPOOL NO. 343b MANHOLE NO. 1A TEAM: C

CRACK NO.	LOCATION	DESCRIPTION	REMARKS
1	@ Start joint 3:00	JOINT CRACK 19"	
2	@ start joint 9:00	JOINT CRACK 18"	
3	@ L/2 full circumfrance	HOOP CRACK	
4	@ end joint 3:00	JOINT CRACK 40"	
5	@ end joint 9:00	JOINT CRACK 30"	

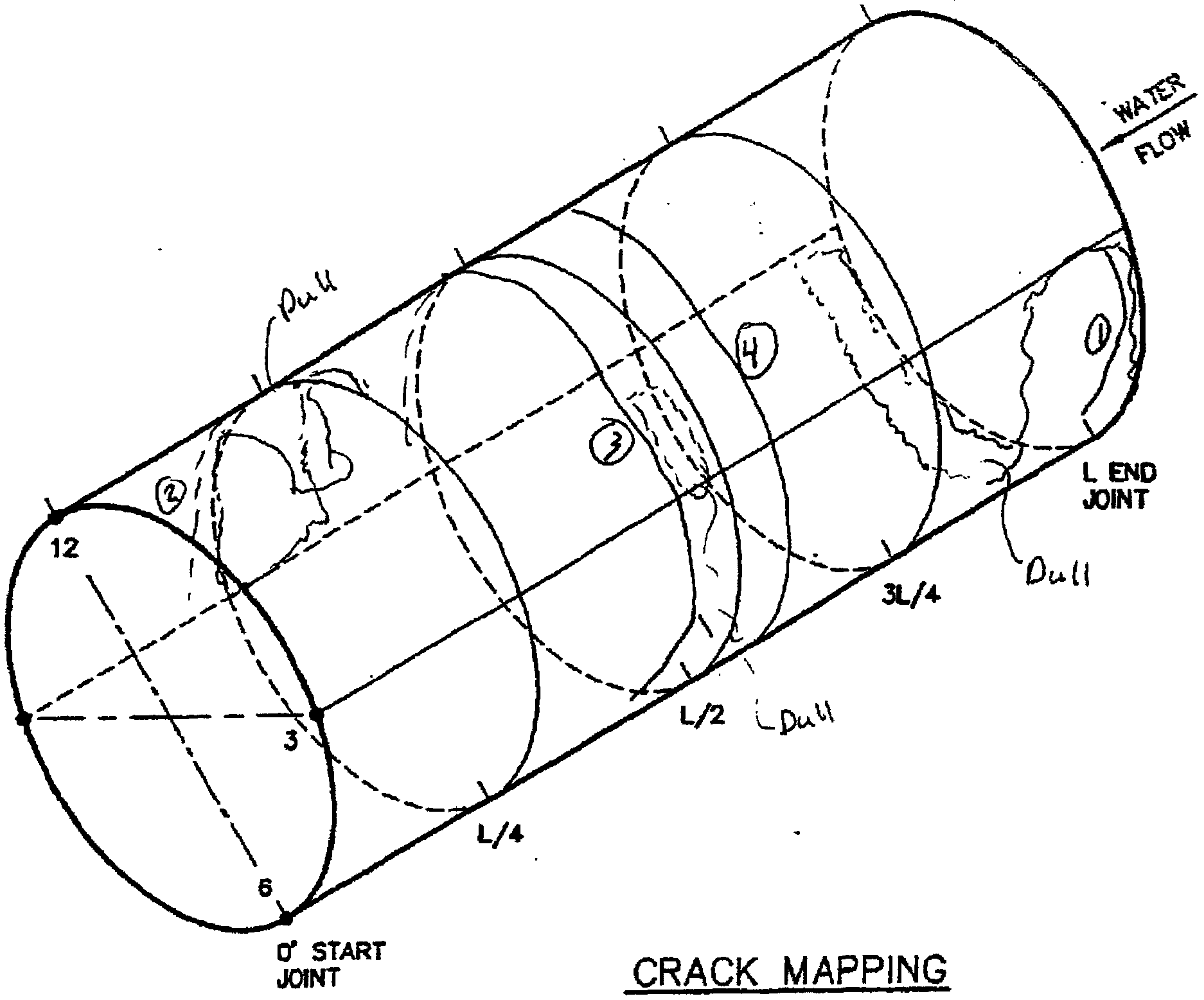


CRACK MAPPING

77' = 924"

SPOOL NO. 343A | MANHOLE NO. | TEAM : C

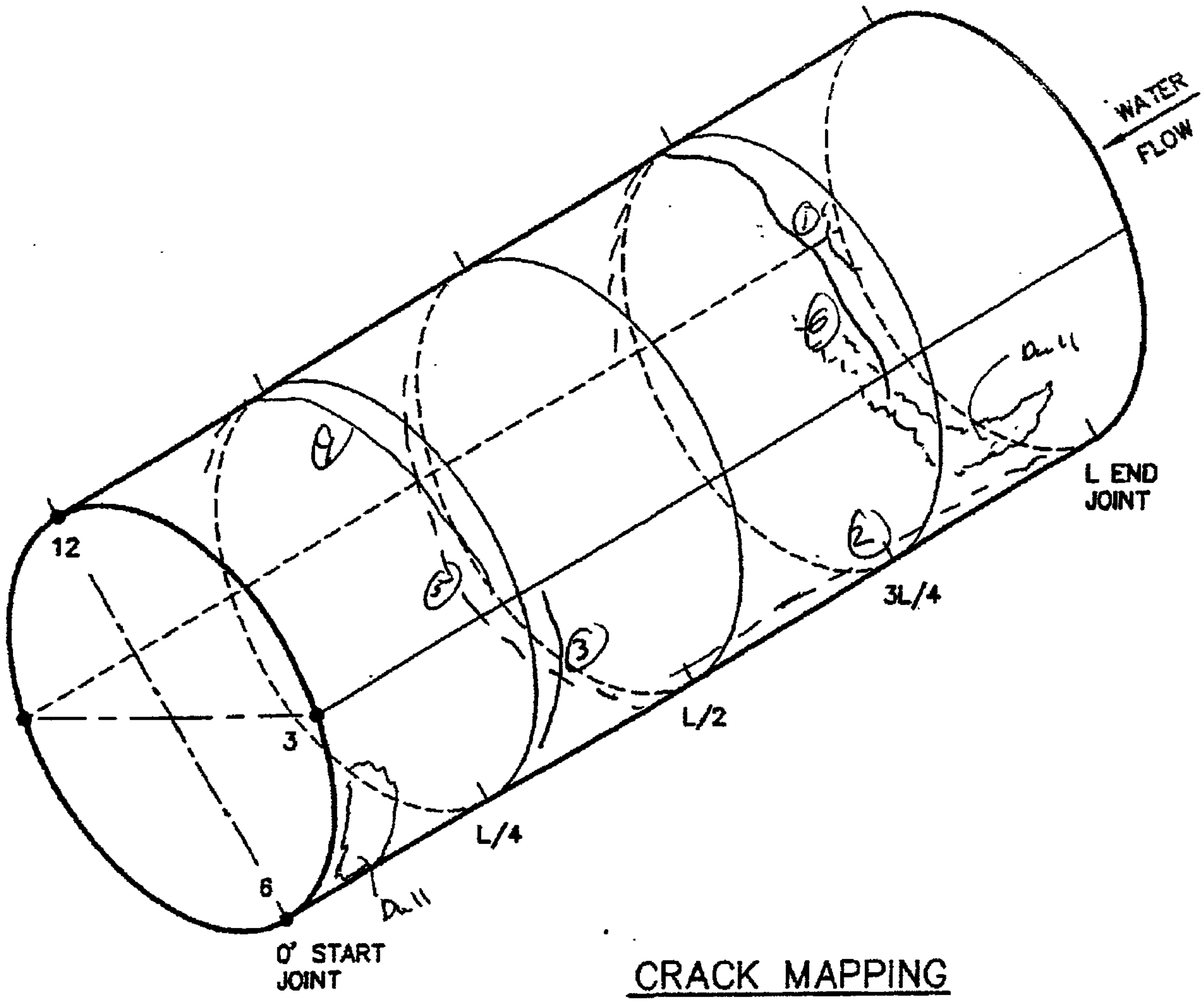
CRACK NO.	LOCATION	DESCRIPTION	REMARKS
1	L/2 - 3L/4 12h	spiral crack	~~[illegible]~~
2	L/4 - L/2 12h	spiral crack	
3	9 o'clock 3L/4 to mid start	length crack	8 feet
4	~~[illegible]~~ 8 to 10 o'clock L END	joint crack	2 feet



CRACK MAPPING

61'

SPOOL NO. 316 B		MANHOLE NO. 1B	TEAM D
CRACK NO.	LOCATION	DESCRIPTION	REMARKS
1	3-5	MICROCRACK	
2	9-11 7'	MICROCRACK	
3	9-5 20'	MICROCRACK	
4	12-7 20'	MICROCRACK	

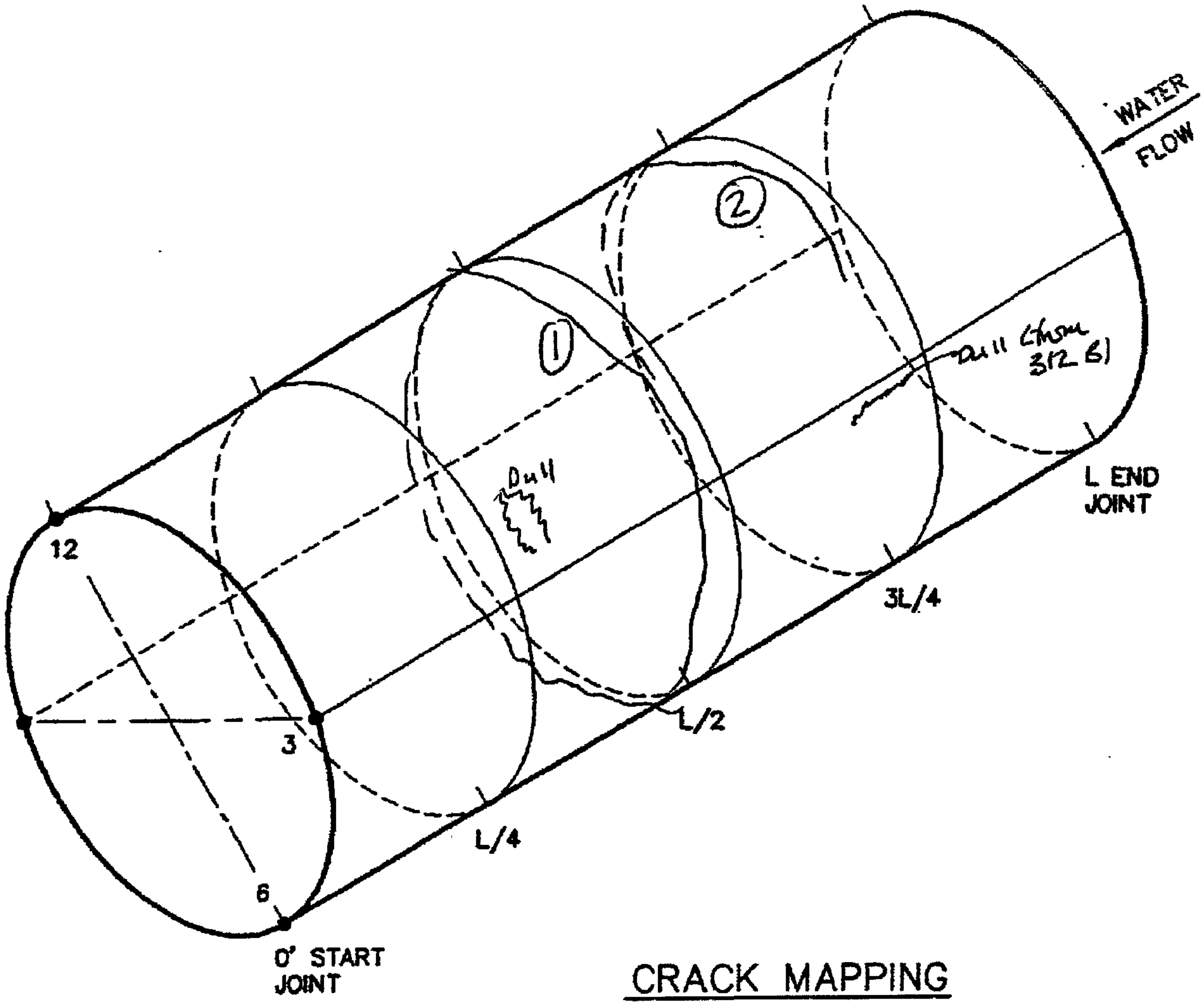


CRACK MAPPING

50'

SPOOL NO. 314B MANHOLE NO. 1B TEAM D

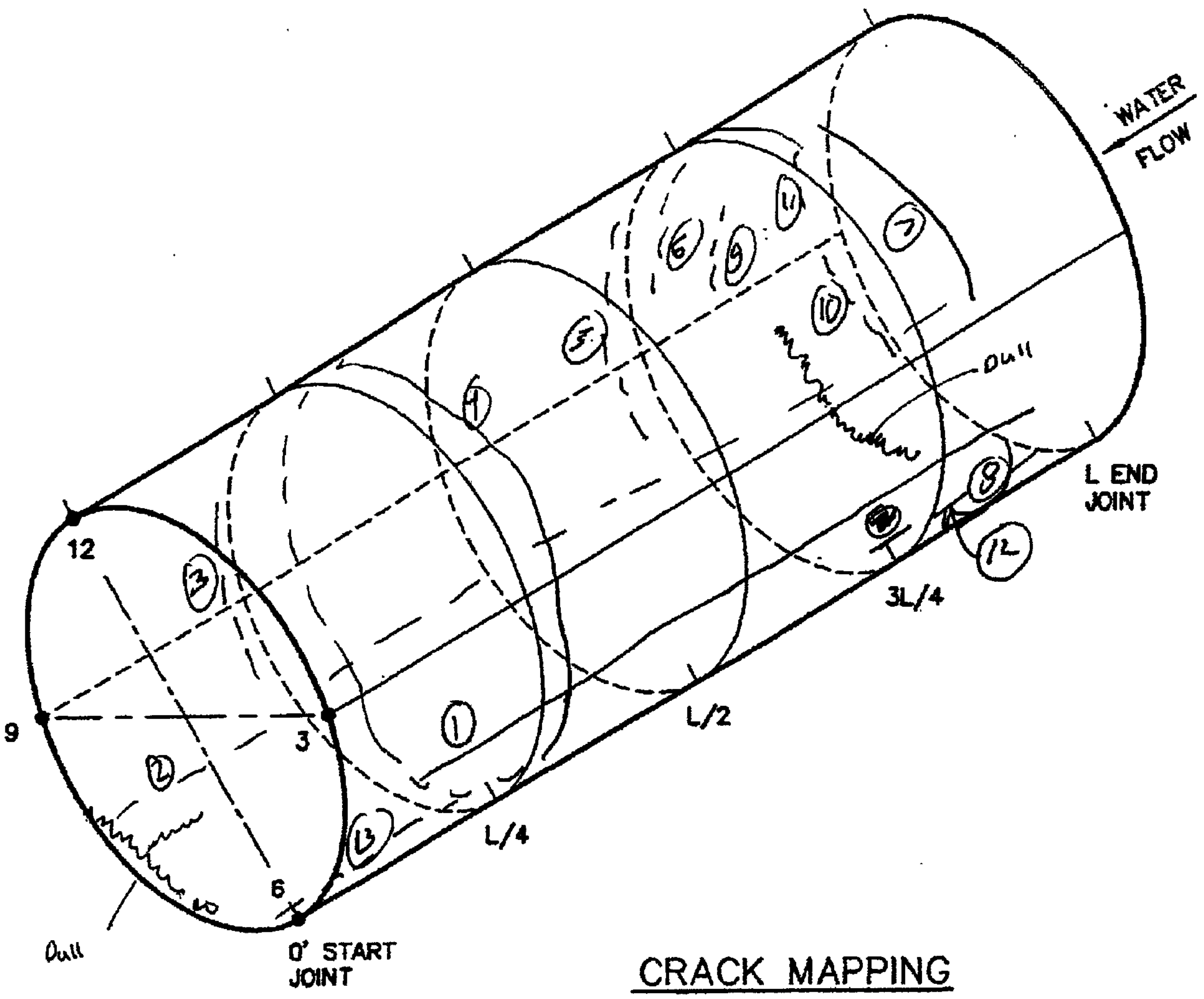
CRACK NO.	LOCATION		DESCRIPTION	REMARKS
1	9	2'	JT. CRACK	
2	6	8'	MICROCRACK	
3 4	3-5 11-3	5' 10'	MICROCRACK MICROCRACK	
5 6	6-10 9-4	10' 15'	MICROCRACK MICROCRACK	



CRACK MAPPING

44' ✓

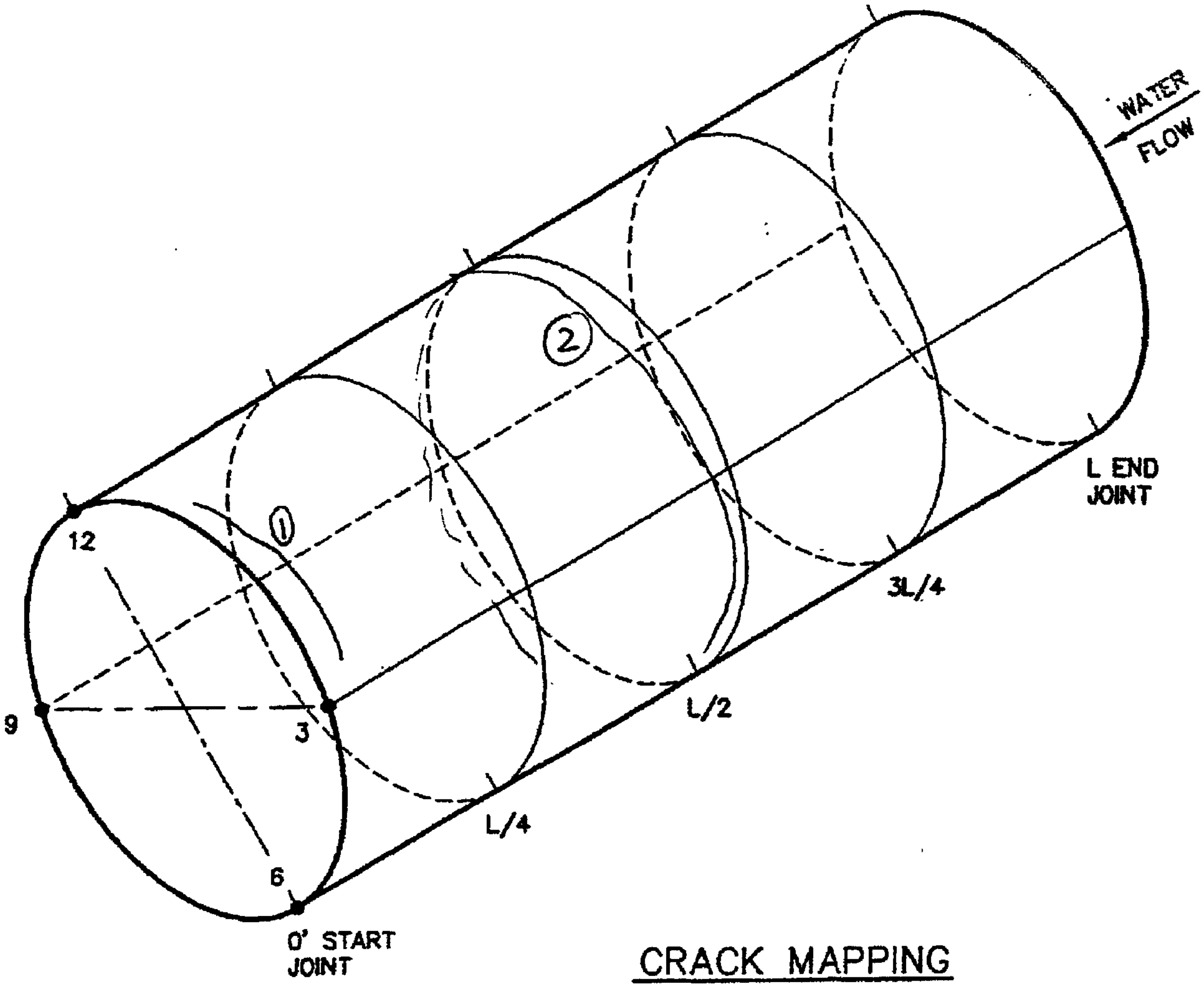
SPOOL NO. 313A		MANHOLE NO. 1B	TEAM D
CRACK NO.	**LOCATION**	**DESCRIPTION**	**REMARKS**
①	HOOP CRACK 12-12 32'	HOOP CRACK	PATCH BETWEEN 10-12 7'
②	8-1 12'	MICROCRACK	



CRACK MAPPING

110' L

SPOOL NO. 312 B		MANHOLE NO. 1B	TEAM D
CRACK NO.	**LOCATION**	**DESCRIPTION**	**REMARKS**
1	4 15'	LARGE CRACK	PATCH (16FT)
2	8 15'	LARGE CRACK	PATCH FROM L/2-L (16FT)
3	8-10 5'	MICROCRACK	
4	12-12 32'	HOOP CRACK	
5	7-10 6'	MICROCRACK	
6	10-1 8'	MICROCRACK	
7	1-3 6'	MICROCRACK	
8	4-6 4'	MICROCRACK	
9	9-10 3'	MICROCRACK	
10	7-8 2'	MICROCRACK	
11	9 1'	MICROCRACK	
12	6 6'	LARGE CRACK	PATCH (8FT)



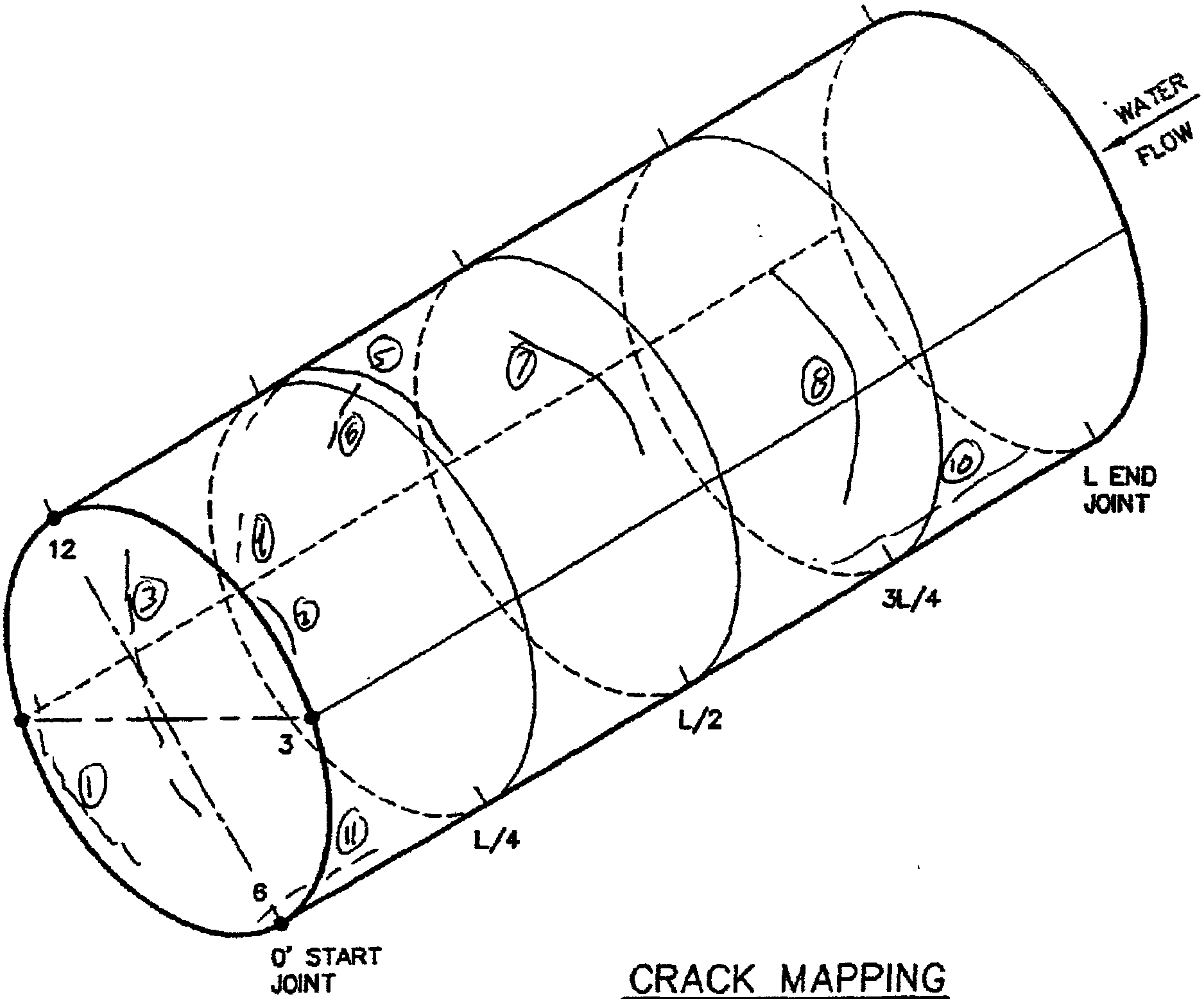
CRACK MAPPING

5'

TEAM E

SPOOL NO. 5 MANHOLE NO. 1B ~~TEAM D~~

CRACK NO.	LOCATION	DESCRIPTION	REMARKS
1	1-3 5'	MICROCRACK	
2	7-4 25'	HOOPCRACK	



CRACK MAPPING
58' V

SPOOL NO. 8 MANHOLE NO. 1A TEAME

CRACK NO.	LOCATION		DESCRIPTION	REMARKS
1	7-9	5'	JT. CRACK	
2	4	2'	JT. CRACK	
3	8-10	8'	MICROCRACK	
4	10	1'	MICROCRACK	
5	11-1	6'	MICROCRACK	
6	10	2'	MICROCRACK	
7	1-2	4'	MICROCRACK	
8	2-4	4'	MICROCRACK	
9	8-1	15'	MICROCRACK	
10	6	8'	CRACK W/EPOXY	PATCH
11	~~8~~ 6	3'	MICROCRACK	

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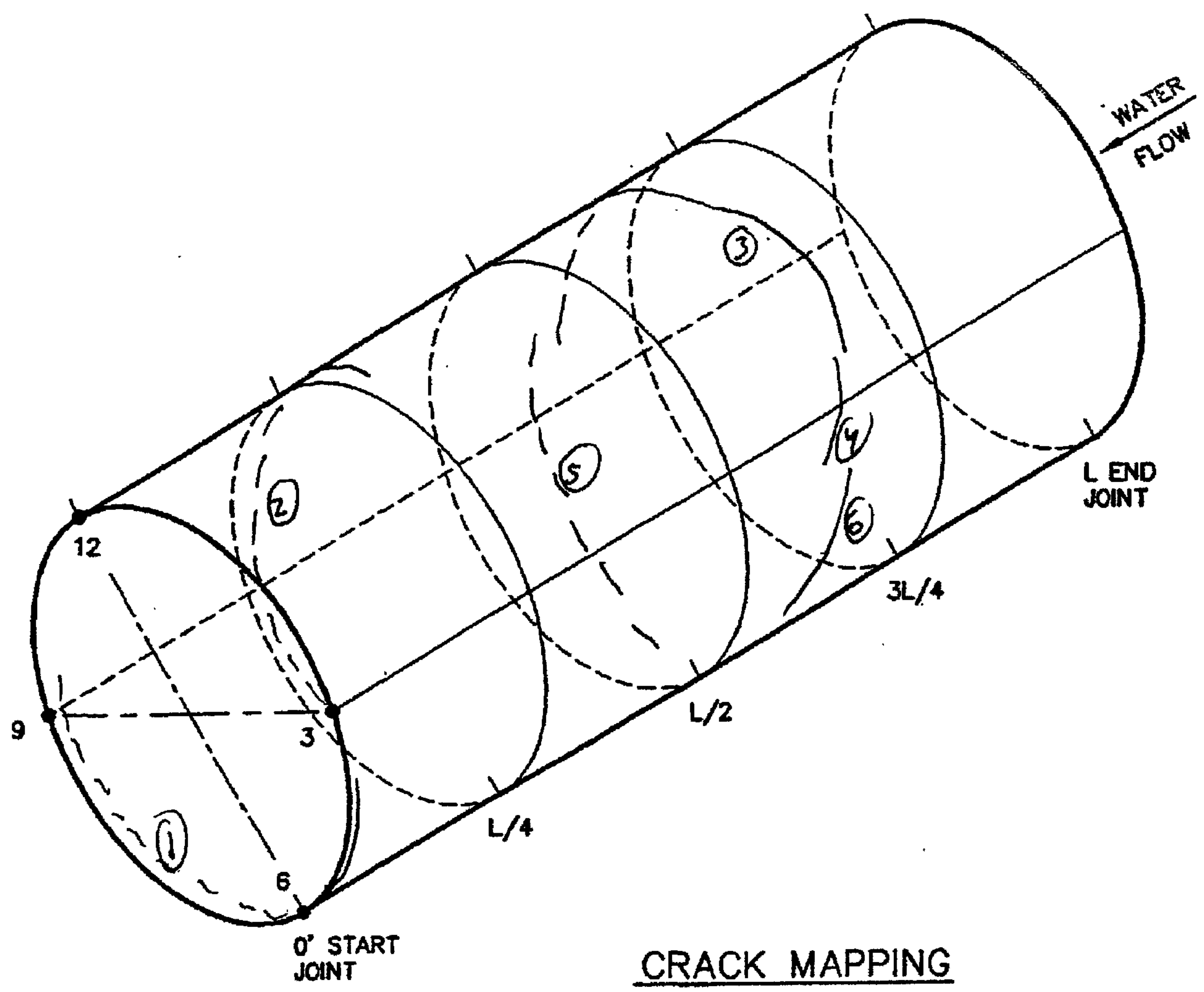
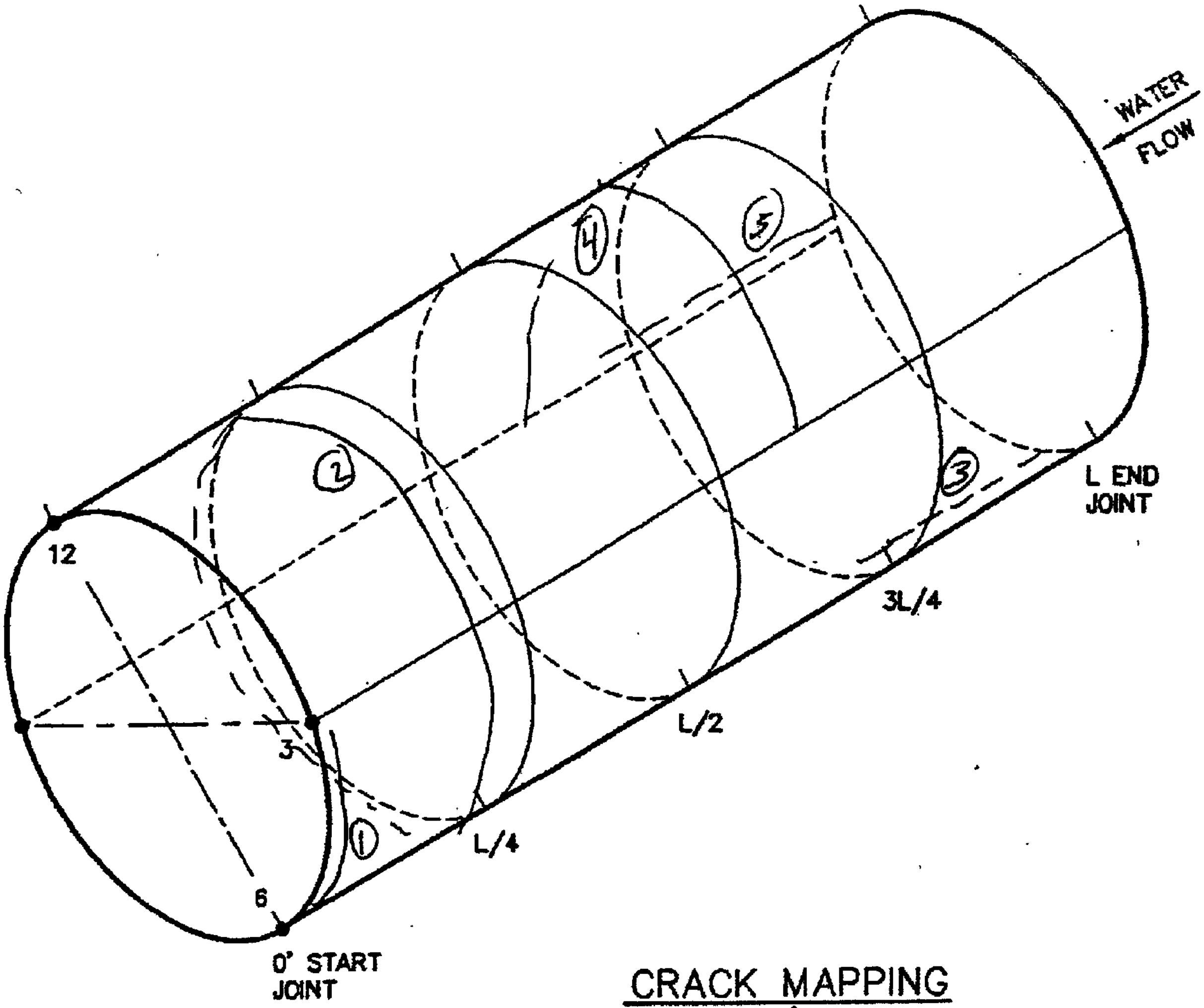


CRACK MAPPING
70'

SPOOL NO. 13 MANHOLE NO. 1B TEAM E

CRACK NO.	LOCATION		DESCRIPTION	REMARKS
1	4-10	15'	JT. CRACK	
2	7-2	18'	MICROCRACK	
3	10-2	12'	MICROCRACK	3, 4, 5, + 6 HOOP CRACK
4	2-3	3'	MICROCRACK	
5	7-10	6'	MICROCRACK	
6	4-6	16'	MICROCRACK	

IP12_003657

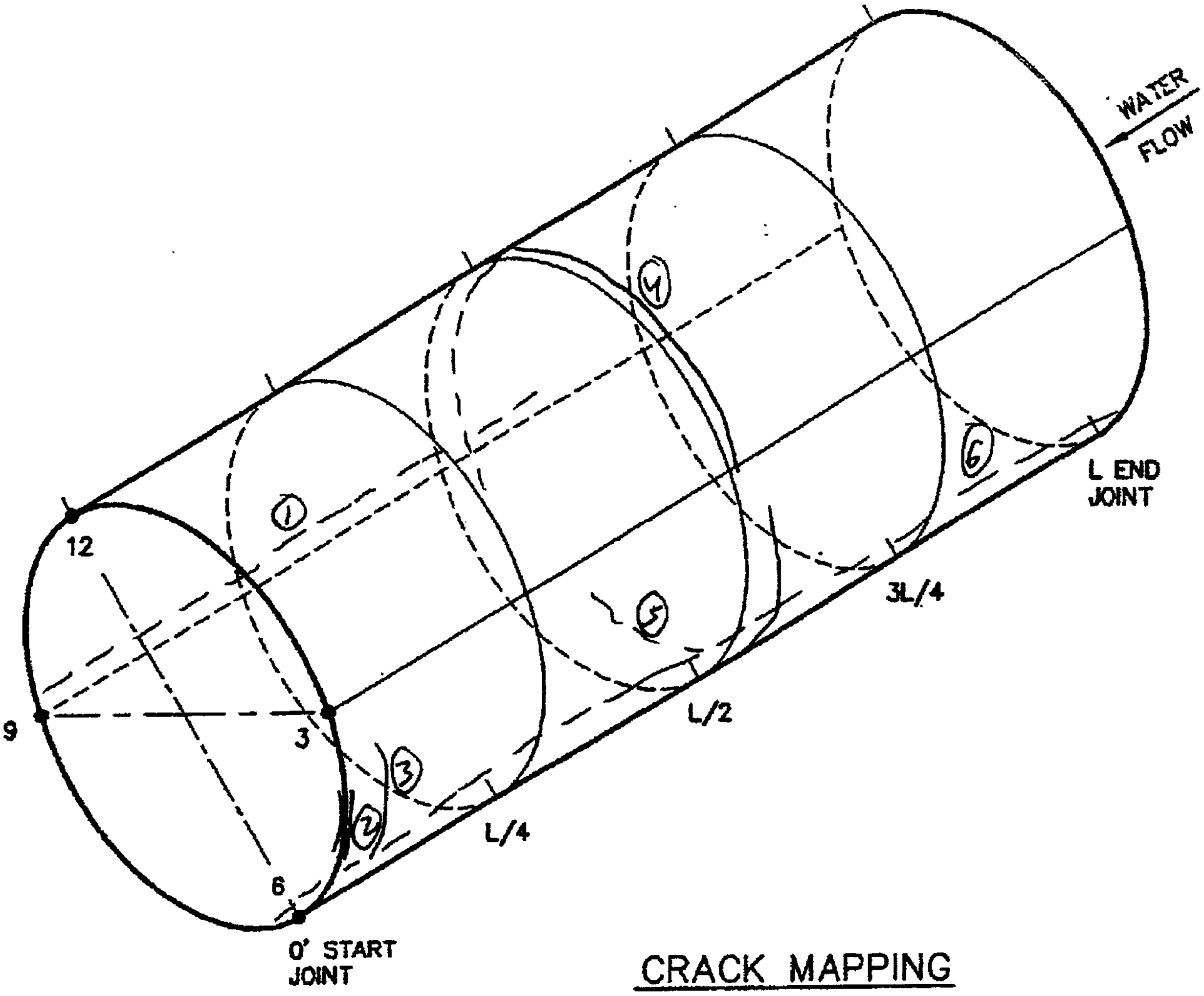


CRACK MAPPING

69' ✓

SPOOL NO. 16 MANHOLE NO. 1A TEAM E

CRACK NO.	LOCATION		DESCRIPTION	REMARKS
1	4-6	8'	JT. CRACK	
2	12-12	32'	HOOP CRACK	
3	6	6'	LARGE CRACK	PATCH (8FT)
4	9-3	15'	MICROCRACK	
5	9	8'	LONG. CRACK	PATCH (8FT)

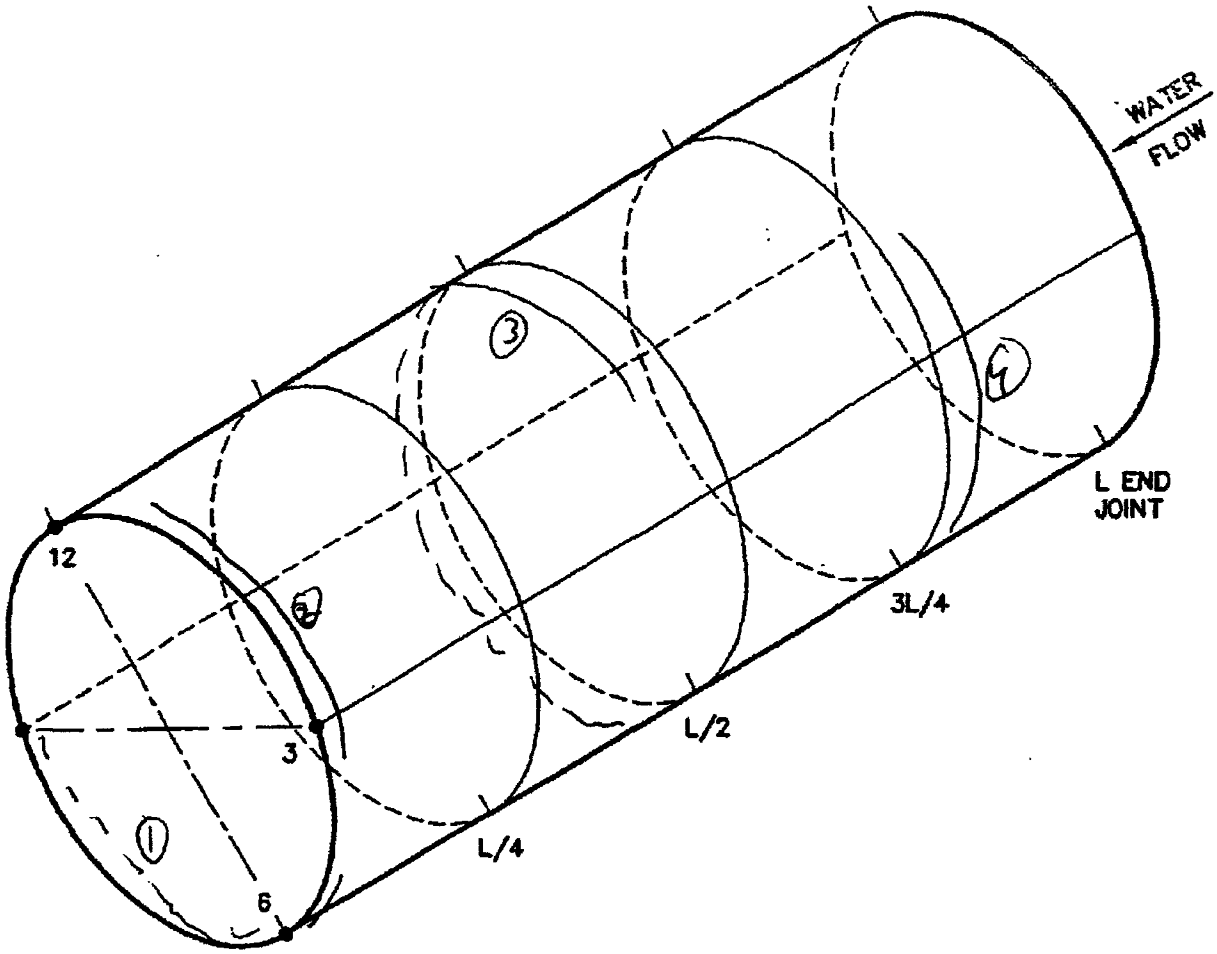


CRACK MAPPING

59'L

SPOOL NO. 17 MANHOLE NO. 1B TEAM E

CRACK NO.	LOCATION		DESCRIPTION	REMARKS
1	9	12'	LONG. CRACK	PATCH 12FT
2	3-4	1'-6"	JT. CRACK	
3	3-4	3'	MICROCRACK	
4	8-3	18'	HOOP CRACK	
5	3-6	8'	MICROCRACK	
6	6	16'	LONG. CRACK	PATCH 16FT



CRACK MAPPING

54'

SPOOL NO. 19 MANHOLE NO. 1B TEAM E

CRACK NO.	LOCATION	DESCRIPTION	REMARKS
1	3-9 16'	JT. CRACK	
2	1-3 10'	MICROCRACK	
3	6-2 20'	HOOP CRACK	
4	2-5 8'	MICROCRACK	

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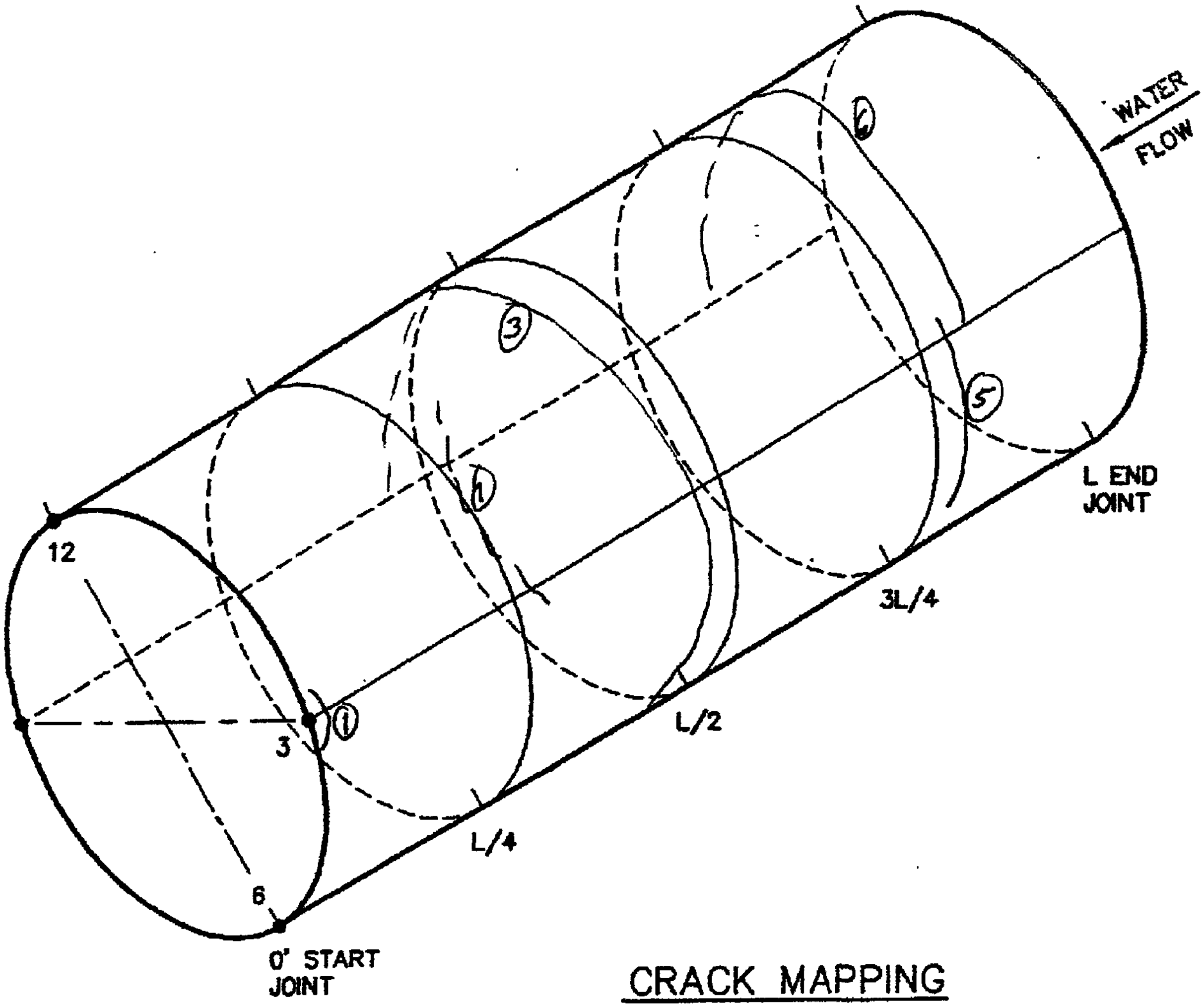

CRACK MAPPING

64'V

SPOOL NO. 21 MANHOLE NO. 1B TEAM E

CRACK NO.	LOCATION		DESCRIPTION	REMARKS
1	3	1'	JT. CRACK	
2	5-7	8'	JT. CRACK	
3	9-6	24'	HOOP CRACK	
4	6-9	8'	MICROCRACK	
5	3-5	7'	MICROCRACK	
6	9-3	16'	HOOP CRACK	

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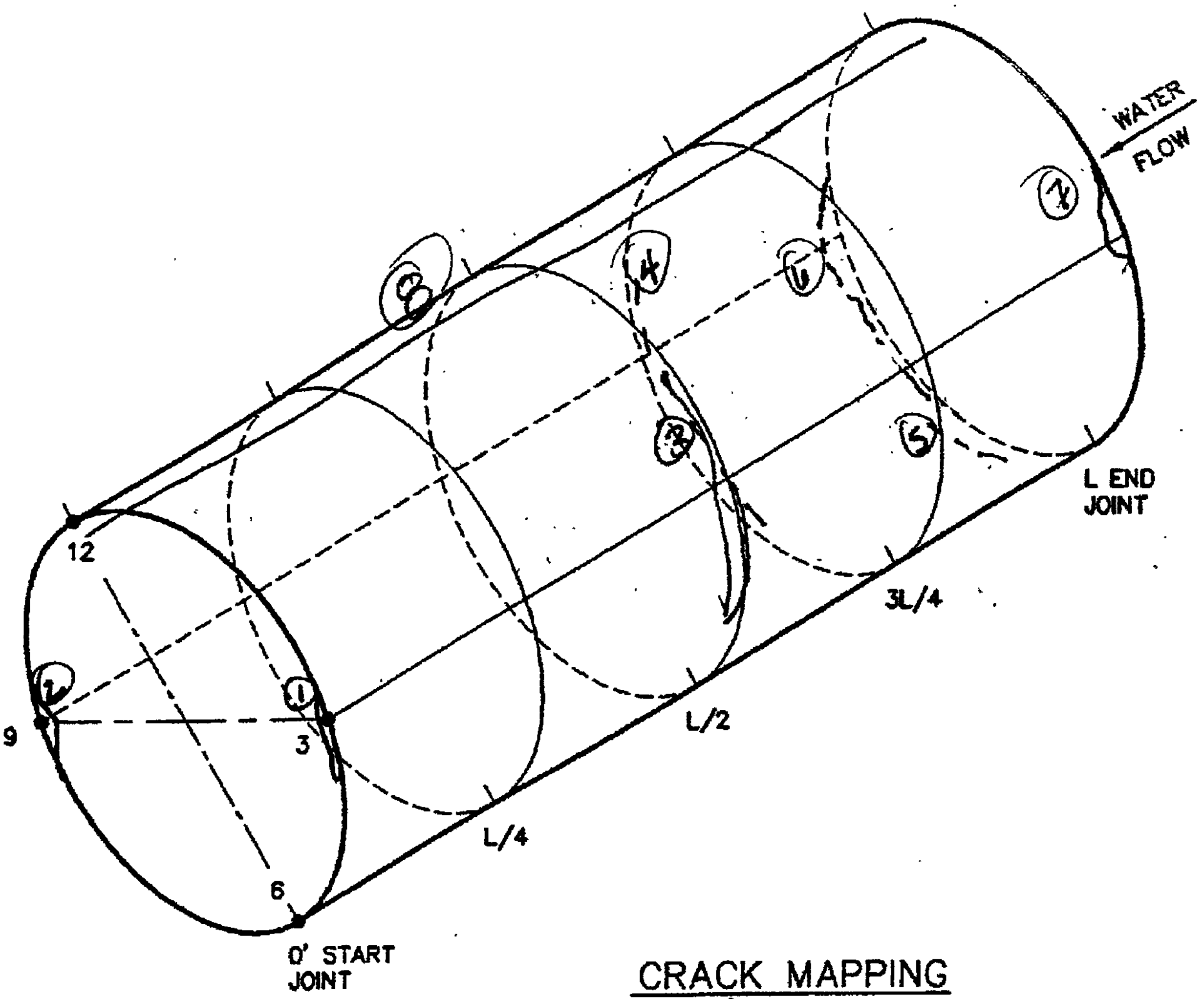
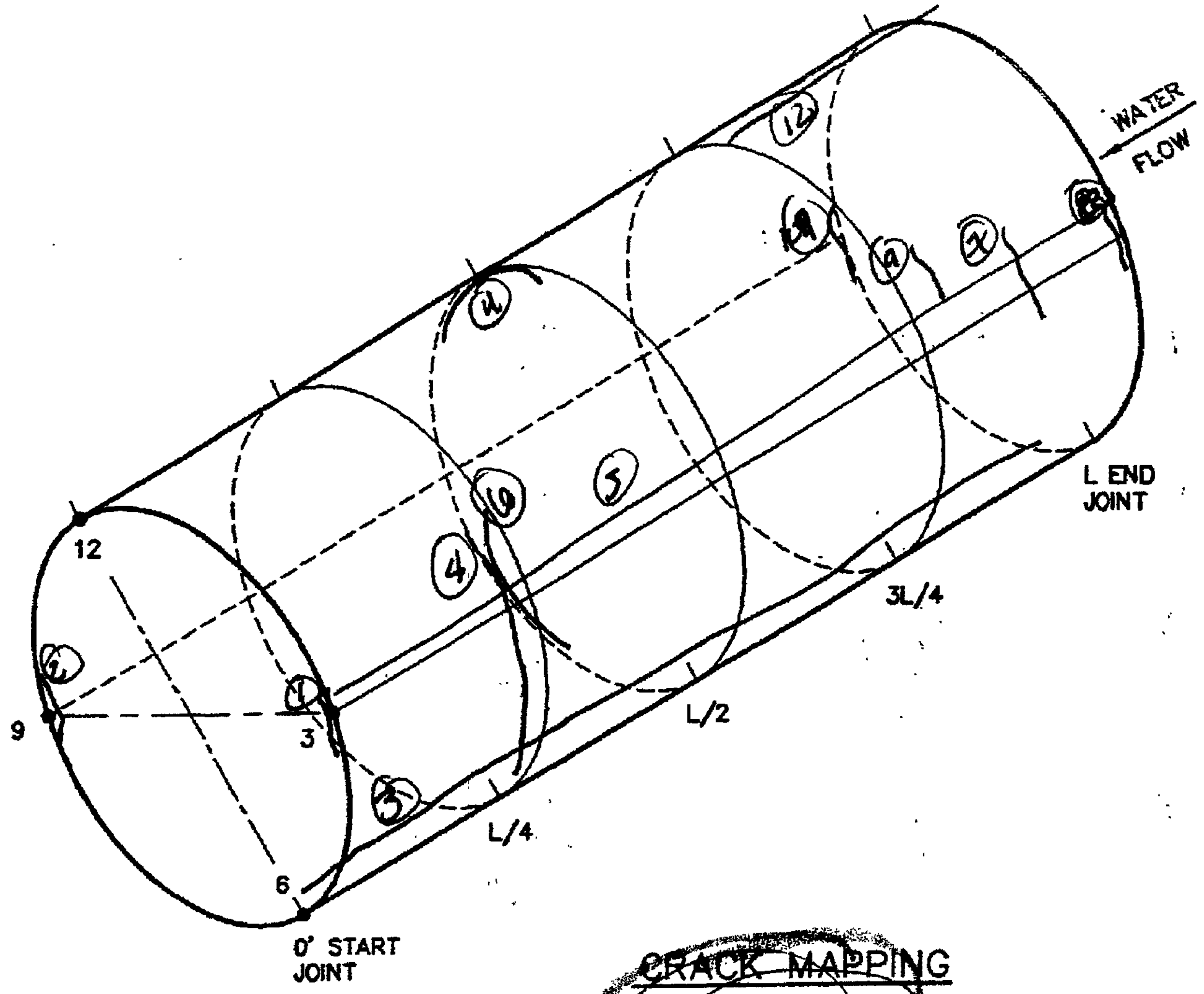


CRACK MAPPING

~~28~~ 54' ✓

SPOOL NO. 35 MANHOLE NO. 1B TEAM F

CRACK NO.	LOCATION	DESCRIPTION	REMARKS
1	@ start joint 3:00	joint crack 27"	
2	@ start joint 9:00	joint crack 29.5"	
3	@ L/2 1:00-4:00	1/4 circ. microcrack 74.5"	
4	@ 3L/4 8:00 -10:00	micro 72"	
5	@ 3L/4 6:00-7:00	micro 22.5"	
6	@ end joint 7:00	micro 12"	



CRACK MAPPING

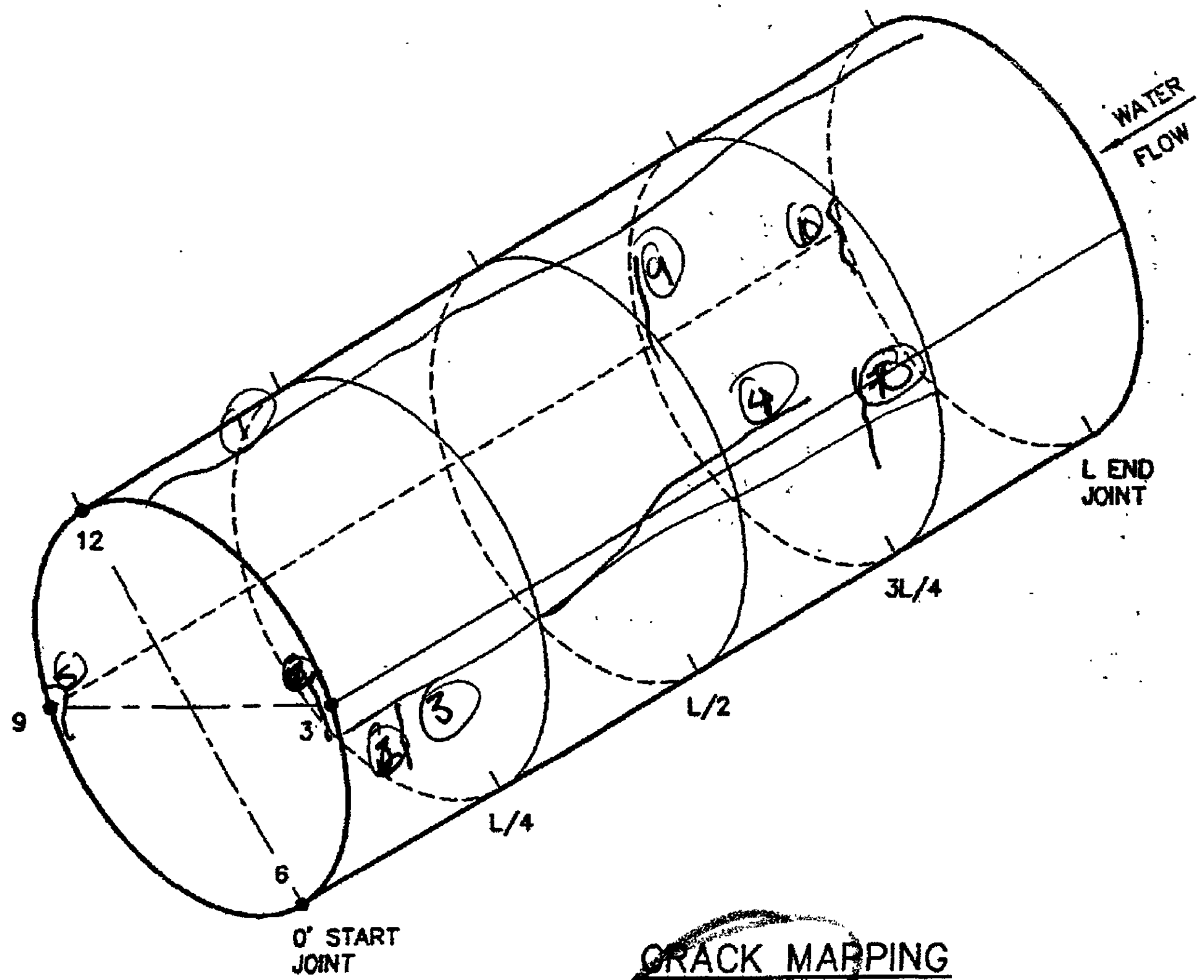
244'

SPOOL NO. 36 MANHOLE NO. 1B TEAM F

CRACK NO.	LOCATION	DESCRIPTION	REMARKS
1	Joint Crack 3:00-400	crack joint 36"	joint is wet along bottom
2	joint crack 9:00	crack joint 24"	"
3	5:00 Start - end	long. crack	patch 16 FT
4	1/4 5:00-3:00	micro 75.5"	
5	Start - 3/4 3:30	long. crack 132"	patch 16 FT
6	1/2 2:00-9:00	micro 54"	

7	34/4 3:00	micro 27"
8	@ end joint 3:00	joint 28"
9	@ 34/4 ~~7:00~~ 2:00	micro 16"
10	end joint 9:00	joint crack 29"
11 ~~10~~	42 1:00 11:00	micro 59'
12	42 ~~34/4~~ end 1:00	long

343D1 343B1 344A



CRACK MAPPING

75'

SPOOL NO. 37 MANHOLE NO. 1B TEAM F

CRACK NO.	LOCATION	DESCRIPTION	REMARKS
1	Start - end 1:00	long crack	patch open damp 16FT
2	@ start joint 7:00-4:00	joint crack 40"	
3	Start - 3L/4 4:00	long 130"	patch 12FT
4	L/4 - 3L/4 4:00 - 3:00	long. 7'	patch 8FT
5	@ Start 3:00	Joint crack ~~48"~~ 37"	
6	@ ~~S~~ start 4:00	micro ~~2~~ 12"	

7	34/4 2:00-400	micro 23"
8	34/4 7:00-9:00	micro 48"
9	10:00-11:00 34/4	micro 27"
10	endjoint 9:00	joint crack 12"
11	end joint 3:00	joint crack

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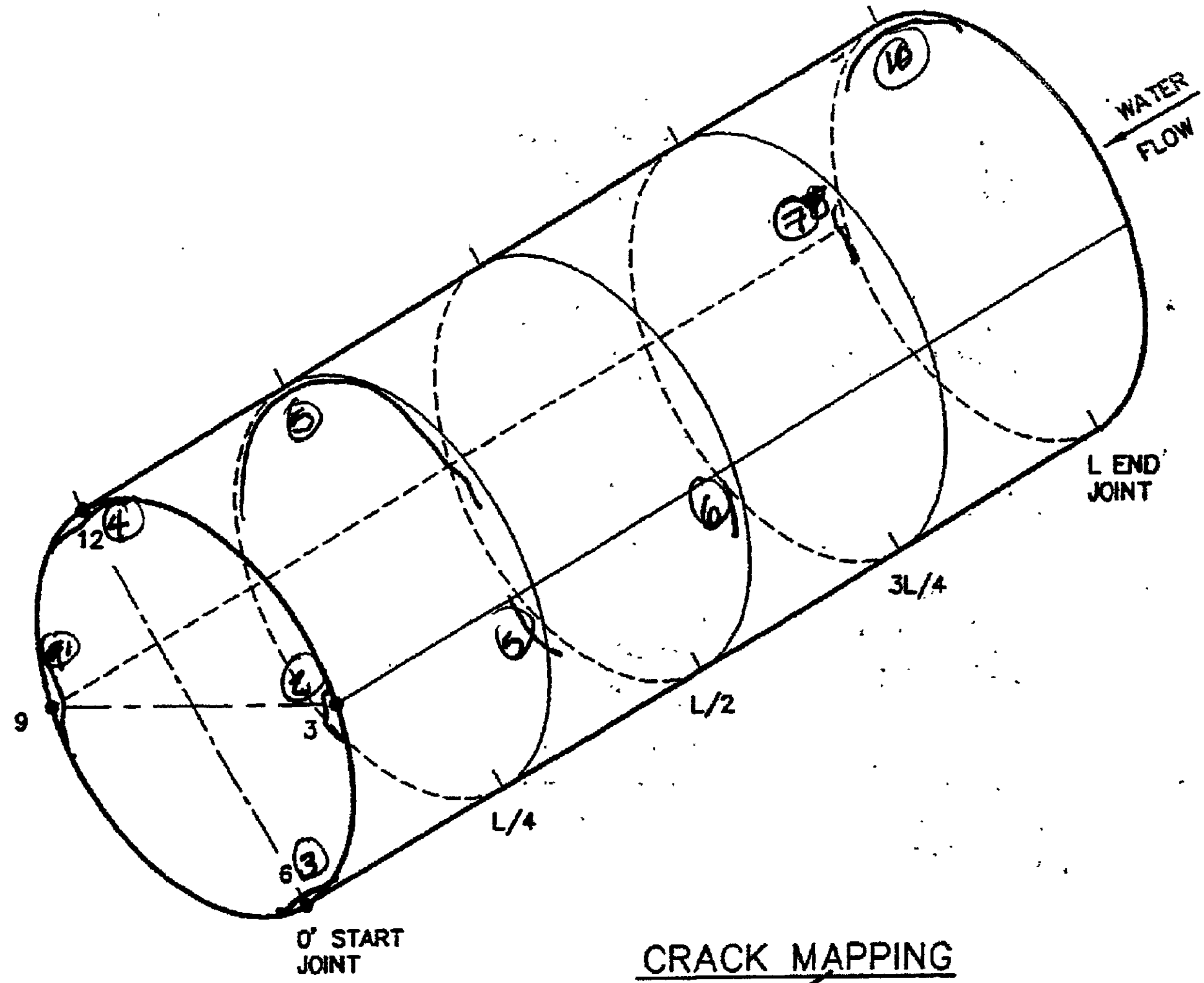


CRACK MAPPING

48' ✓

SPOOL NO. 38 MANHOLE NO. 1B TEAM F

CRACK NO.	LOCATION	DESCRIPTION	REMARKS
1	@ start joint 7:00-10:00	joint crack ~~48"~~ 63"	needs more sandblasting!
2	@ start joint 4:00-3:00	joint crack 26"	joints damp
3	@ start joint 5:00	joint crack 17"	DAMP
4	@ start joint 12:00	joint crack 28"	
5	44 ~~Redo~~ 8:00-2:00	1/2 hoop	
6	42 4:00	micro 17"	

7 @ endjoint 9:00 — joint crack 19.5"

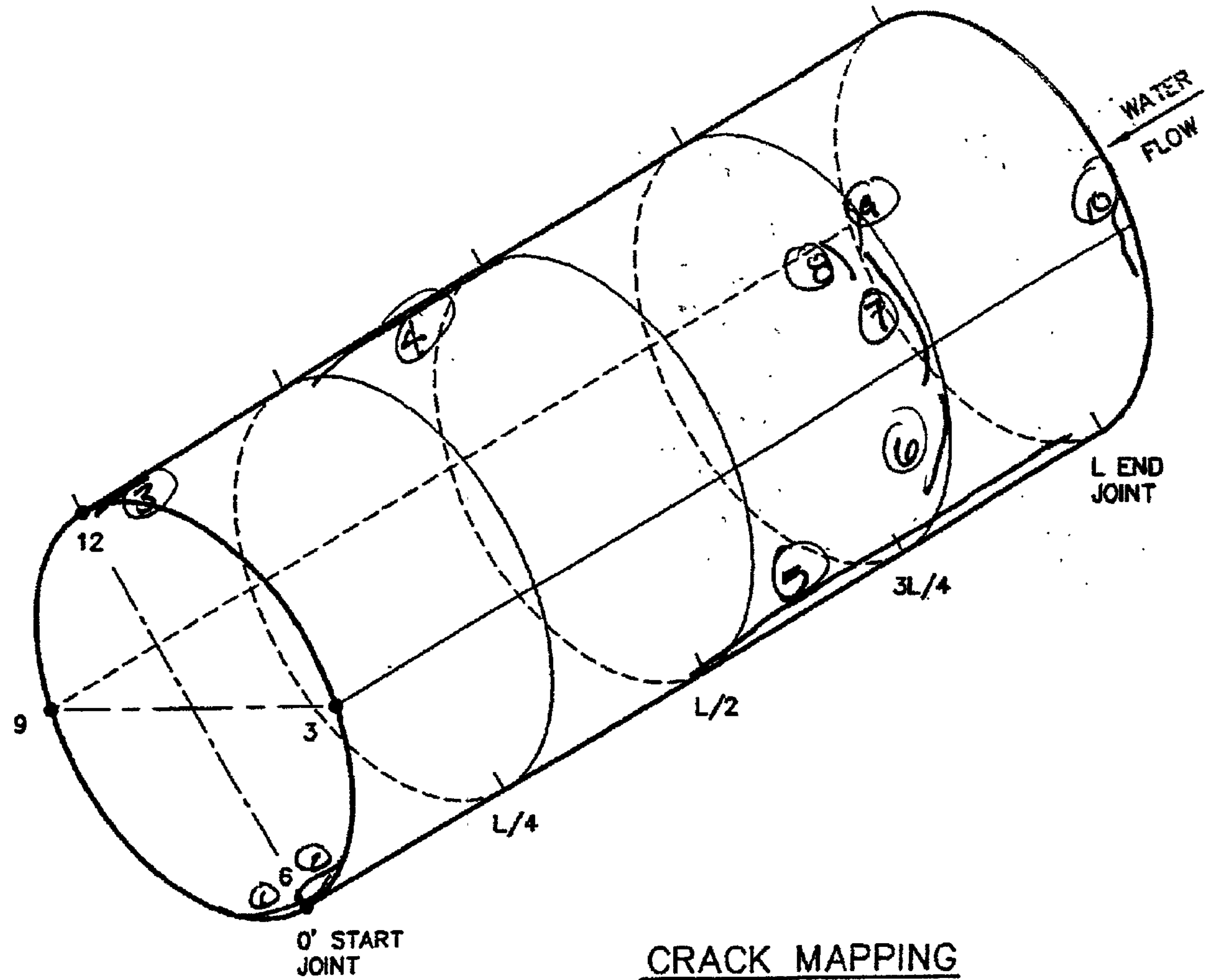
8 @ endjoint 12:00-9:00 — joint crack 79"

9 @ end 9:00 — joint 39"

10 @ endjoint 6:00-8:00 — joint 33"

11 @ endjoint 11:00-1:00 — joint crack 52"

IP12_003668

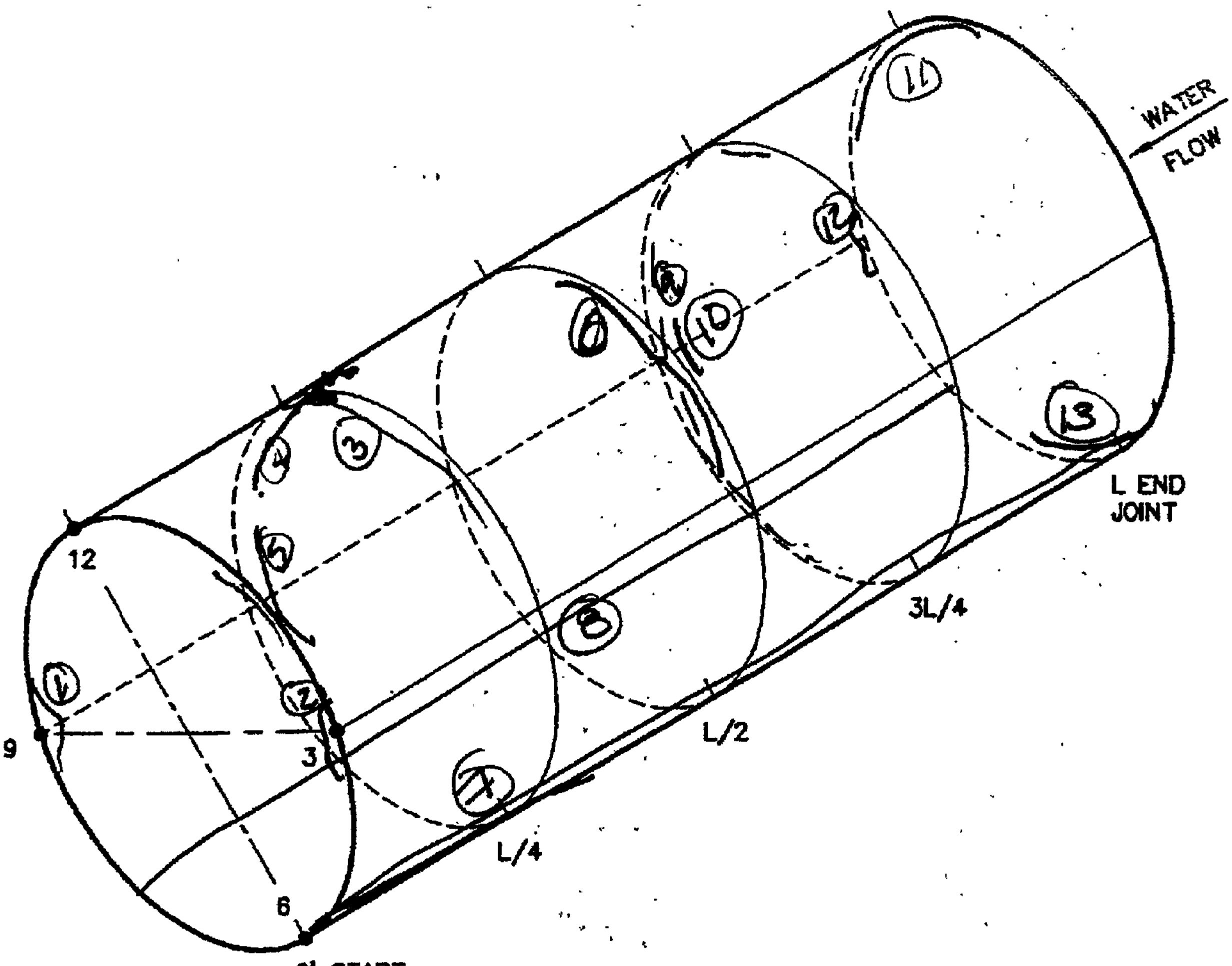


CRACK MAPPING
~~48~~' 39' L

SPOOL NO. 39 MANHOLE NO. 1B TEAM F

CRACK NO.	LOCATION	DESCRIPTION	REMARKS
1	@ Start joint 5:00 - 7:00	Joint crack ~~36"~~ 72"	
2	@ start joint 7:00	joint crack 36"	
3	@ start - 12:00	long crack along seam 7"	open
4	@ 1/4 - 1/2 12:00	" " 25'	open
5	1/2 - end joint 10:00	long crack 130"	
6	3/4 4:00 - 5:00	micro 25"	

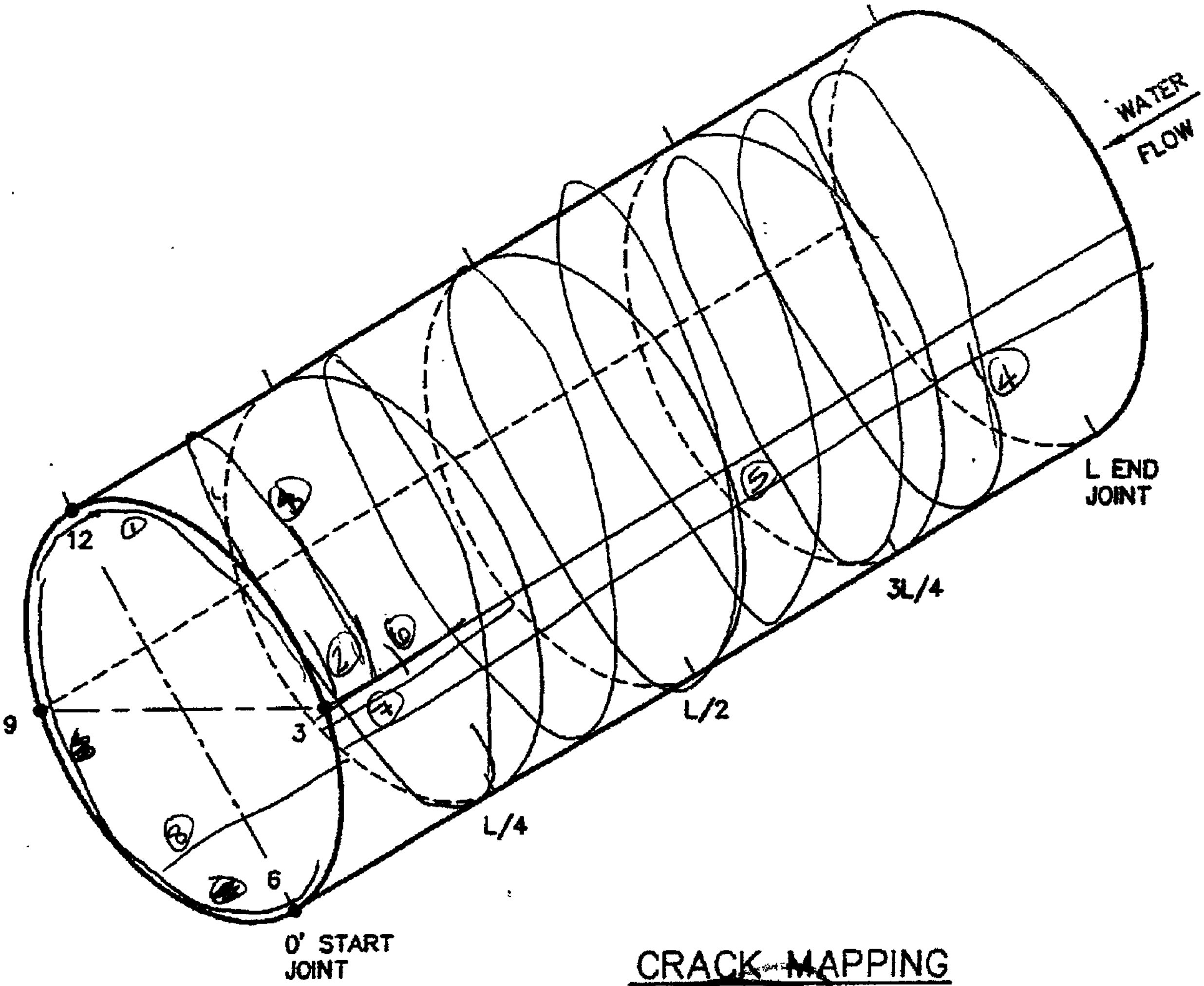
7	34/4 2:00-4:00	micro ~~54~~ 80"
8	34/4 2:00	micro 10.5"
9	@ end joint 9:00	joint 22.5"
10	@ end joint 3:00	joint 50"



CRACK MAPPING
97'

SPOOL NO. 41 MANHOLE NO. 1 B TEAM F

CRACK NO.	LOCATION	DESCRIPTION	REMARKS
1	@ Start joint 9:00 - 8:00	Joint crack 46"	
2	@ ~~E~~ Start joint 3:00	Joint Crack 33"	
3	44 2:00 - 12:00	micro 57.5"	
4	44 1200 - 1000	micro 71"	
5	44 900 - 700	micro 36"	
6	42 1:00 ~~[illegible]~~ 300	micro 56"	

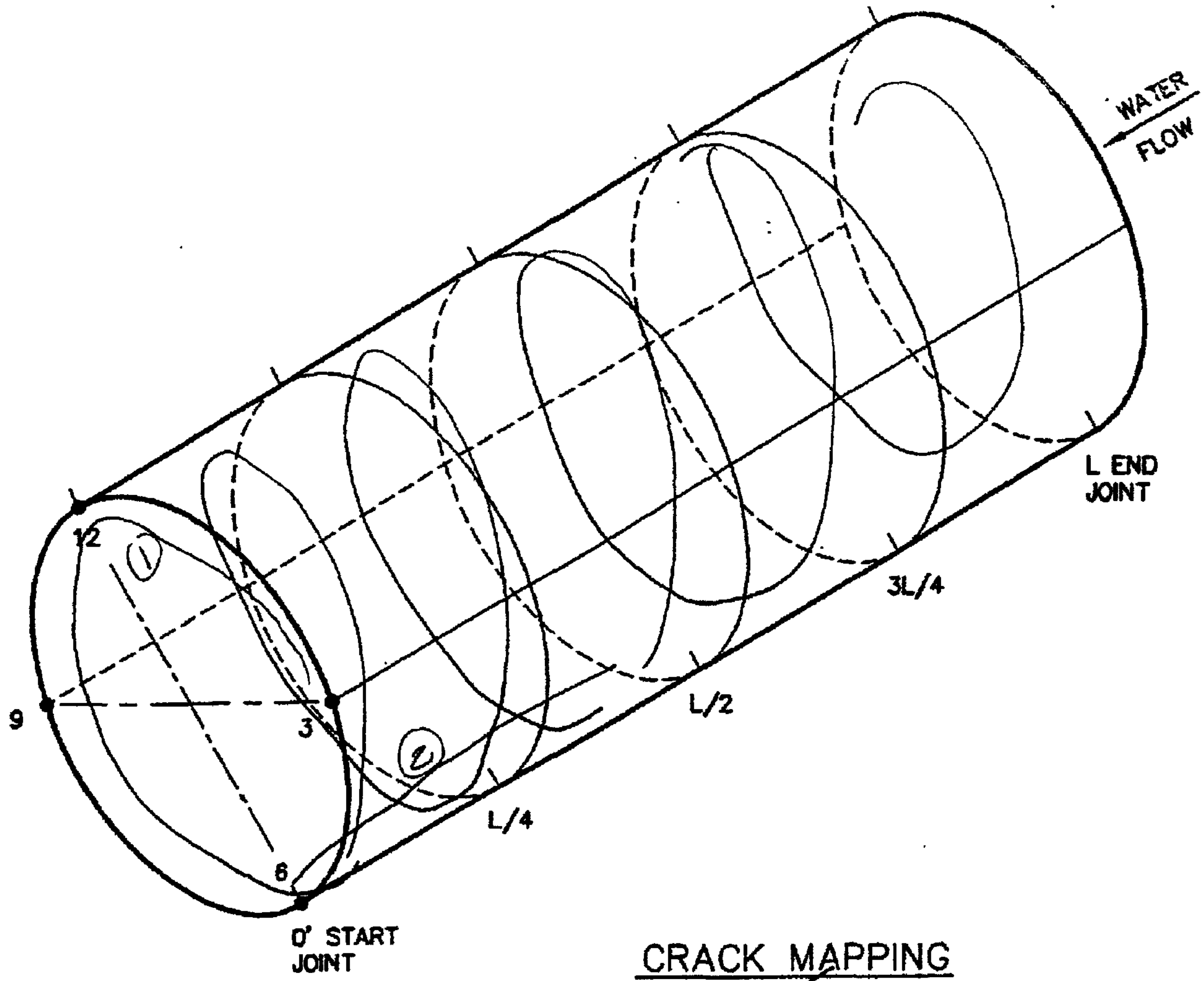


CRACK MAPPING

207'

SPOOL NO. 53 MANHOLE NO. 1b

CRACK NO.	LOCATION	DESCRIPTION	REMARKS
1	Start joint [illegible] 2-5	joint/hoop crack 3/4 circ	
2	Start joint ~~[illegible]~~' 3:00	open crack 1.5'	open
3	Start joint 3:00	long 2'	open
4	between 0 & L/4 4:00-6:00	spiral crack ~~3/4 circ~~	open - 6 loops
5	Start - End 4:00	Long - full length	open
6	L/2 8:00	mirco - 1.5'	
7	L/4 - L/2 8:00	long - 3.5'	
8	0 - L/4 7:00	long - 3'	
9	end joint ~~4~~:00-8:00	joint crack 3/4 circ	
10	Start - L/4 4:00	long - 5'	
11	Start - L/4 5:00	long - 6.5'	
12			
13			
14			
15			
16			
17			
18			



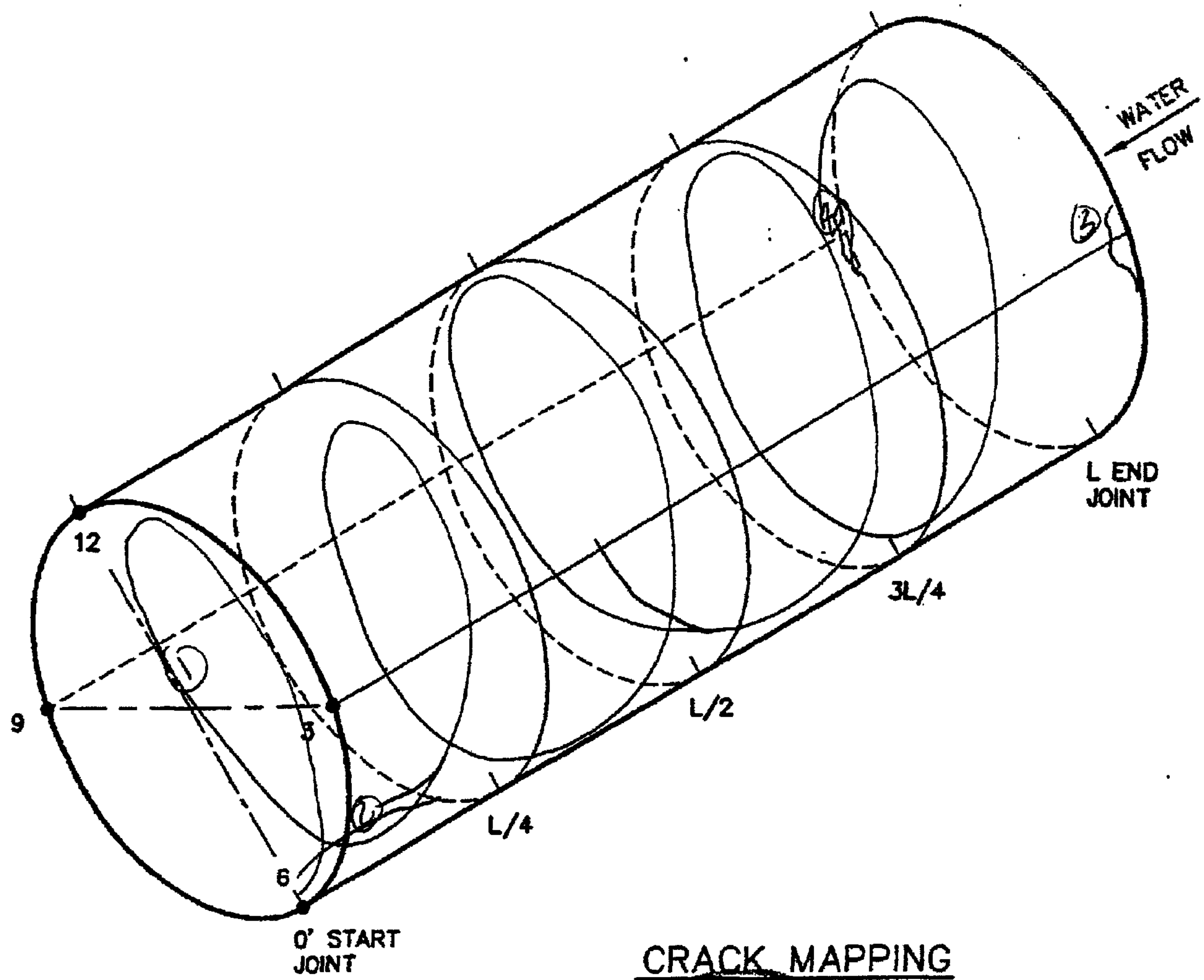
CRACK MAPPING

122'

84'

SPOOL NO. 60 MANHOLE NO. 1b

CRACK NO.	LOCATION	DESCRIPTION	REMARKS
1	Start to end ~~3~~:00 9:00	spiral crack - 5 hoops	open - cont. to pipe 61
2	Start - ~~3~~44 6:00	long. crack 7.5'	
3	344 ~~6:00 3:00~~ 3:00 - 400	micro - 4'	

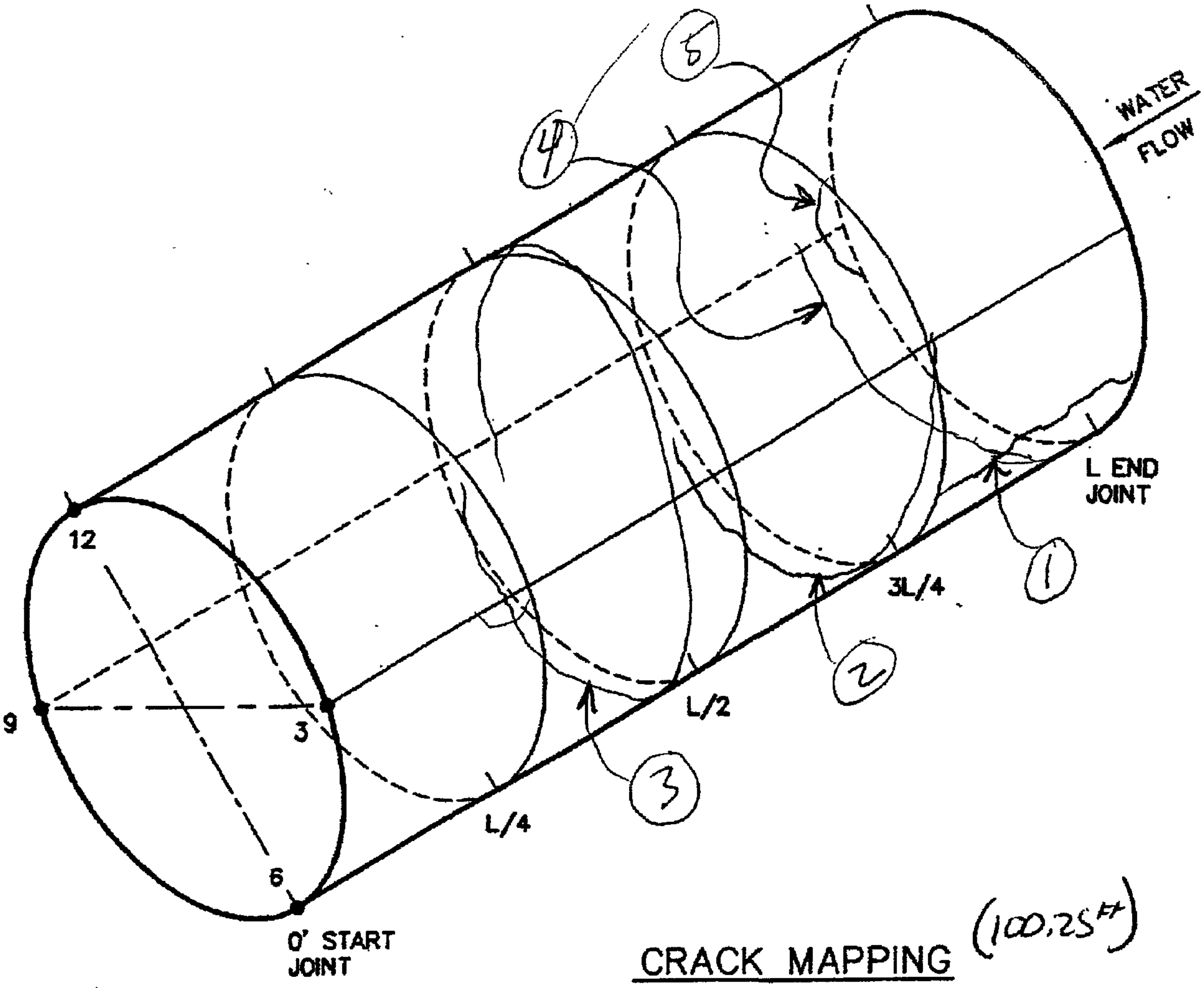


CRACK MAPPING

145'

SPOOL NO. 61 MANHOLE NO. 1b

CRACK NO.	LOCATION	DESCRIPTION	REMARKS
1	Start - 3/4 6:00-9:00	spiral crack - 4½ hoops	open - cont. to next pipe - damp @ 3'
2	Start - 44 6:00	long - 4.5'	damp
3	end 2:00-4:00	joint crack - 3.5'	
4	end - 9:00	joint crack - 2'	



CRACK MAPPING (100.25 ft)

114" ϕ 16' LONG GROUP "G"

SPOOL NO. 129 MANHOLE NO. 1A

CRACK NO.	LOCATION	DESCRIPTION	REMARKS
1	4' LONG @ 6:30 O'CLK	> 3/32" CRACK / CONSTR. JT.	PATCH REQ'D. 5'-0
2	3:00 O'CLK TO 8:0'CLK 4'-6" FROM END JT.	> 3/32" SPIRAL HOOP CRACK	PATCH REQ'D 31'-9
3	8:00 O'CLK 7' FRM START JT. TO 8:00 O'CLK 7' FRM END JT. SPIRAL CRACK	> 3/32" CRACK - HOOP SPIRAL CRACK	PATCH REQ'D 31'-9
4	6:00 O'CLK TO 9:00 O'CLK 12" FRM END JT.	> 3/32" CRACK - HOOP TYPE	PATCH REQ'D 31'-9
5	JT. CHIP CRACK AT 9:00 O'CLK	< 3/32" CRACK	

IP12_003675

CORRPRO COMPANIES INC.	CORROSION PROTECTION DESIGN FOR CIRCULATING WATER PCC PIPELINES	CORRPRO COMPANIES INC Preserve and Sustain Global Assets & Infrastructure
	INTERMOUNTAIN POWER SERVICE CORPORATION	

CORROSION PROTECTION DESIGN
FOR
CIRCULATING WATER
PRESTRESSED CONCRETE CYLINDER PIPELINES

January 2006

CLIENT : INTERMOUNTAIN POWER SERVICE CORPORATION
LOCATION : DELTA, UTAH
CONTRACT NO. : 05-45642

CORRPRO COMPANIES INC.					
7000 B Hollister					
Houston, TX					
Tel: (330) 460-6000	A	Issued For Client Approval	1-06	DDG	
Fax: (330) 460-6060 **Email: dgallagher@corrpro.com**	**Rev**	**Description**	**Date**	**By**	**Appv.**

IP12_003676

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<u>Appendices</u>

1 INTRODUCTION

Corrpro Companies Inc. has been retained by Intermountain Power Service Corporation to provide a corrosion control design for the 60", 72", 84" 120" and 144" diameter pre-stressed concrete cylinder (PCC) pipelines associated with the circulating water supply and return cooling system.

The scope of this report includes a discussion of the field investigations performed at the power plant facility and the requirements for a corrosion control system inclusive of design parameters, calculations, material specification, bill of materials list, installation drawings and construction installation scope of work.

The proposed corrosion control system will be offered for bid for material procurement and construction installation. Quality control of the system installation shall be provided by IPSC or their nominated contractor.

2 SUMMARY of FIELD INVESTIGATION

2.1 Electrical Continuity Of PCC Pipelines

Electrical continuity testing was performed on the PCC circulating water supply and return pipelines in March of 2005 and the results of the tests conclude that the PCC pipelines are electrically discontinuous within themselves and also between themselves. The results of these tests are discussed in a separate report. To enable cathodic protection to be effectively applied for corrosion protection, these pipelines must be made electrically continuous within and between themselves.

An electrical continuity testing and bonding program is presently being initiated by IPSC for the PCC pipelines associated with the circulating water cooling system. Within the pipeline, electrical continuity bonds are welded across the bell and spigot joints of isolated sections of PCC pipe to make them electrically continuous. An inter-pipe bonding arrangement is provided as part of the corrosion protection design, and will provide electrical continuity between each of the 4 subject circulating water pipeline structures. The program begins with the scheduled plant shutdown in April 06 and will be finalized during the annual scheduled maintenance shutdown of Unit 1 in April of 2007.

2.2 Soil Resistivity and Soil Chemical Analysis

2.2.1 Soil Resistivity

Field and laboratory testing were performed to collect chemical and electrical data pertaining to the corrosivity of the soil conditions surrounding the PCC pipelines.

Soil resistivity measurements were recorded from grade to depths of five, ten, fifteen and twenty feet on approximate 500 foot intervals along the pipeline route.

Soil samples were recorded at 12 representative bore hole locations along the pipeline right of way. These data are recorded in Appendix B, Data Table E.

Based on analyses of the electrolyte characteristics, the soil is corrosive with respect to PCCP. The soil resistivities at the elevation where the pipe is installed are corrosive ranging from 499 to 21065 ohm-cm, with 57 % of the measurements less than 3,000 ohm-cm and 28 % of the measurements less than 1,000 ohm-cm at the 20 foot depth.

The Prestressed Concrete Cylinder Pipe (PCCP) is subject to corrosion in the soil encountered along the pipeline alignment and therefore, the application of cathodic protection is well suited to provide corrosion mitigation to these pipeline structures.

2.2.2 Soil Analysis

Twelve (12) soil samples collected along the pipeline right-of-way were tested in the laboratory for moisture content, pH, chloride ion concentration, sulfide ion concentration, conductivity and resistivity. Laboratory test results are tabulated in data table E of Appendix B.

With respect to the chemical properties of the soil, the test results of the samples indicate:

- Moisture content from 8.3% to 29%.
- A pH range from a minimum of 8.3 to a maximum of 9.9.
- Chloride ion concentrations from 6 to 960 ppm.
- No detectable sulfide ions.

- Conductivities from 160 to 6,000 micromhos.
- Resistivities from 170 to 10,000 ohm-cm.

Considering each of the chemical and electrical soil properties that are tested in the field and the laboratory, general guidelines for interpreting the results are as follows:

- Soil Moisture - The higher the soil moisture content, the greater the anticipated rate of corrosion. Moisture contents can range from 1% (very dry sands) to 40% (clays holding a great deal of moisture). Typical values are 10 to 15% with over 20% moisture considered high.
- pH - Acidic soils and groundwater are more conducive to galvanic corrosion of ferrous materials than alkaline soils and groundwater.
- Conductivity - For a given corrosion cell with a fixed potential difference between the anode and cathode, the higher the conductivity, the greater the metal loss. Conductivities over 350 micromhos/cm (equivalent to a resistivity of 2850 ohm-cm) are considered high.
- Sulfide Concentration - Any detectable concentrations of sulfide ions are indicative of anaerobic conditions that may support high rates of metal dissolution due to microbiologically influenced corrosion.
- Chloride Concentrations - Chloride ions are cathode depolarizers which enhance the rate of corrosion. The higher the concentration, the greater the rate of corrosion. Many soils have chloride concentrations less than 10 ppm. Concentrations over 50 ppm are significant from a corrosion standpoint.
- Soil Resistivity - Resistivity is a common parameter for evaluating the corrosiveness of the soil. Resistivity is the inverse of conductivity and is measured in units of ohm-centimeters. Corrosivity is often an inverse function of resistivity with low resistivity soils usually more corrosive than high resistivity soils. Resistivity is also related to the concentration of salts with low resistivity indicating high levels of salt.

It should be stressed that there is no single chemical or electrical property of the soil that determines the rate of corrosion. Consideration of the interrelationship of all of the above factors is important to an accurate assessment of the potential rates of corrosion and the design of a corrosion protection system.

2.2.3 pH of Mortar

Samples of the mortar coating were removed from cut out sections of damaged pipe and tested for pH in the laboratory and ranged between 12.0 to 12.3. This high pH value of pH provides corrosion protection for the embedded steel components of the PCC pipe. However, in areas where soil resistivities are low and chloride contents are high, the corrosion protection afforded by the mortar coating will be compromised, making the embedded steel susceptible to corrosion.

2.3 Corrosion Protection Requirements

An analysis of the field data obtained during the survey was made to determine the requirements for the corrosion protection system that should be considered for the circulating water PCC pipelines for the Intermountain Power Project.

Areas of low resistivity, high moisture content, and/or high chloride content indicate ferrous materials will be subject to electrochemical corrosion, and this phenomenon has been observed and documented by IPSC. It is recommended that cathodic protection be installed for corrosion protection to mitigate the corrosion observed on these pipeline structures.

An electrical continuity bonding program is presently being initiated by IPSC to establish and maintain electrical continuity for the PCC circulating water pipelines associated with Units 1 and 2. This work will be finalized after the scheduled shutdown of Unit 1 in April of 2007.

In addition to providing electrical continuity and cathodic protection for corrosion control of the pipelines, monitoring test stations must be installed at regular intervals along the length of the pipeline and at the ends of each pipeline to ensure that adequate levels of protection are maintained and/or to ensure that overprotection of the pre-stressing wires does not occur.

To accomplish this, it will be necessary to install permanent reference electrodes at pipe depth directly adjacent to the PCC pipe and at regular intervals along the pipeline ROW. In addition, negative test wires must be connected to each of the four (4) PCC pipes and routed to the reference electrode / test station locations. Test wires can only be installed at existing manhole locations for the circulating water pipelines, and therefore, test wires must be routed and trenched in the soil along the ROW from these manholes to the test station / reference electrode locations.

2.4 Type of Cathodic Protection System

Cathodic protection by the impressed current method utilizing vertical deep anode groundbeds is proposed for this project.

The CP systems will be of standardized design and construction with each deep anode groundbed being energized by one constant current/constant voltage silicon controlled rectifier (SCR) module. Several rectifier modules are housed within a common enclosure to simplify installation on site and minimize the AC power locations. This arrangement will provide for maximum control of DC current distribution along the entire length of the pipeline and at the ends of the pipeline where CP current demands are greater due to other metallic structures concentrated at these areas.

The PCC pipelines are electrically continuous with other underground foreign metallic structures such as the electrical grounding system, other underground metallic pipelines, and reinforcement bars (rebar) associated with building structures and instrument / manhole vaults. Each of these foreign structures will collect (drain) cathodic protection current intended for the PCC pipelines, and must be accounted for when determining the total current required for cathodic protection of the PCC pipeline structures.

The intent is not to cathodically protect these other metallic structures, but to account for the cathodic protection current loss intended for protection of the PCC pipelines. These structures and their estimated surface areas which form a part of this design are provided in Appendix B, data table A - D.

3 CATHODIC PROTECTION DESIGN

3.1 Reference Standards

3.1.1 Cathodic Protection Design

The cathodic protection system is designed in accordance with the recommendations from the following standards:

NACE International Recommended Practice RPO100-2004 Standard Recommended Practice – Cathodic Protection of Prestressed Concrete Cylinder Pipelines

External Protection of Concrete Cylinder Pipe; American Concrete Pressure Pipe Association

3.1.2 Project Specifications

9255.62.2205 Ameron - IPP Concrete Circulating Water Pipe

9255.62.2205.05-10016 Black & Veatch

3.1.3 Project Drawings

The following IPSC project drawings are referenced and provide information related to pipeline dimension, layout and construction.

Drawing No.	Title
9255-9STU-S3311	Structural – Underground Utilities Area L
9255-9STU-S3312	Structural – Underground Utilities Area M
9255-9STU-S3338	Structural – Underground Utilities Area 19
9255-9HRC-M4728	Yard Piping Details CW Towers Unit 1 & 2
9255-9HRC-M4727	Yard Piping Details CW – Turbine Area
9255-1BSU-E5011A	Grounding – Turbine Area- Unit 1
9255-2BSU-E5011A	Grounding – Turbine Area- Unit 2
9255-8BSU-E5401A	Grounding – General Services Building

9255-9BSD-E2759	Grounding – Administration Building
3076-530.4	Manhole Access – For Bonding Details
3076-500.2	Manhole Access – For Bonding Details
3076-641.2	144" End Ring – For Bonding Detail
3076-595.1	72" Ring Flange – For Bonding Detail

3.1.4 Cathodic Protection Project Drawings

The following cathodic protection installation drawings have been developed for this project and provide information on the layout of the CP equipment, proposed cable routing, installation details and electrical schematic diagrams associated with the installations. These drawing numbers will be revised to include specific IPSC drawing numbers when issued.

Drawing No.	Sheet	Title
D1-32461-C	5 of 5	Cathodic Protection System for PCC Circulating Water Pipelines

3.2 Design Parameters

Type of System	: Impressed Current Cathodic Protection
Design Life	: 25 year
CP Current Density:	
- PCC Pipe	: 0.0001 A /ft^2
- Carbon Steel (pipelines and rebar)	: 3 mA / ft^2
- Copper Grounding	: 15 mA / ft^2
Soil Resistivity at Groundbed	: 1000 ohm-cm @ 150 ft depth
Pipeline Dielectric Coating	: None
Anode Groundbed Configuration	: Vertical Deep Anode
MMO Anode Material	: Substrate: ASTM B-338 Grade 1 Titanium Catalyst: Mixed metal oxide
Anode Tubular Dimension	: 1.25" dia. x 48" long
Anode Backfill	: Calcined petroleum cokebreeze
Max Anode Output Capacity	: 7.62 Amp / anode

Anode Depth	: Min. 100 ft below bottom pipe elevation
Criteria for protection	: NACE RP0100 -2004

3.3 Cathodic Protection Arrangement

The flow of current from a DC source to pipeline will be accompanied by a potential difference between earth and the pipeline, the earth being positive (+) and the pipeline being negative (-). The potential difference is used in criterion for cathodic protection. Obtaining the desired potential difference can be accomplished in either of two methods.

- Method 1: By making the pipeline negative with respect to remote earth.
- Method 2: By making the earth positive with respect to the pipe in local areas.

The first method uses what is termed a remote anode groundbed which is typically used to protect long sections of pipeline. The second method utilizes distributed anode groundbeds that provide protection to piping in the immediate vicinity of the anode groundbed.

3.3.1 Remote Groundbeds

Current discharge from an anode will cause voltage drops in the earth between lines radiating from the groundbed. Close to the anode groundbed, the voltage drop per unit distance is relatively high. With distance further away from the groundbed, the voltage drop becomes less and less until no further voltage drops are observed. This location can be considered remote earth and establishes a radius of area of influence surrounding the anode.

The current flowing to the pipeline will also cause a voltage drop in the soil adjacent to the pipeline and there will be an area of influence surrounding the pipeline. When the groundbed can be located far enough away from the pipeline (500 or more feet) where there is no overlap between the two areas of influence (anode groundbed and pipeline) the groundbed can be considered as being remote.

Under these circumstances, current flows from the groundbed into the general mass of earth, which can be considered a resistance-less or infinite conductor. Current then, will flow from the infinite conductor to the pipeline and cause a voltage drop across the resistance between the pipeline and the infinite conductor. This causes the pipeline to become negative to remote earth, and if shifted sufficiently so, will result in cathodic protection of the pipeline.

The only factor which will limit the length of pipeline that can be protected from one groundbed, is the resistance of the pipeline itself. Several factors must be considered be to ensure that full levels of protection are achieved to the structure without over protection as follows:

- The most remote point must meet a minimum instant off potential of -0.85 volt to $Cu/CuSo_4$ electrode or –0.80 to Ag/AgCl electrode.
- The anode groundbed location must maintain potential levels below the hydrogen over voltage potential of –1.0 volts Instant Off for PCC pipe.
- Pipelines having a lower incremental longitudinal resistance (large pipelines) can have longer sections protected from one anode groundbed.

3.3.2 Distributed or Close Coupled Anode Groundbeds

The use of distributed or "close coupled" anode groundbeds are different from the remote anode configuration. Cathodic protection is achieved depending on the area of influence surrounding only the anode groundbed.

Current flowing away from the anode groundbed is at a high density per unit cross section area of earth. This density becomes less and less with distance. The location where the current density is the highest, will have the greatest point-to-point potential drops. The earth will be positive with respect to remote earth and the most positive earth will be closest to the anode.

The intent of close coupled anodes is to position the groundbeds so that the pipelines to be protected pass through the area of influence surrounding the anode groundbed.

3.3.3 Groundbed Design Considerations

This design has utilized the distributed anode design approach for providing cathodic protection to the pipeline structures. This method will allow for greater contol and adjustment of current to the pipelines over the entire length of the pipeline ROW. The anodes will be installed in a deep vertical anode configuration.

The maximum Instant Off potential for this design will be limited to –1.0 volts with respect to a Cu/CuS04 (1.050 to Ag/AgCl) electrode to avoid overprotection of the PCC pre-stressing wires.

3.3.4 Earth Potential Gradient Formula

The following formula has been used to determine the earth potential gradient resulting from the operation of the anode groundbed(s):

$$Vx = (0.5 \times A)(\ln B)$$

$$A = \frac{(I)(P)}{(\pi)(L)}$$

$$B = \frac{\left(\sqrt{L^2 + X^2}\right) + L}{X}$$

Where:

X =	Anode Distance from pipeline (cm)
I =	Anode current output (Amps)
P =	Soil Resistivity (ohm-cm)
π =	3.1415
L =	Active anode length (cm)
Vx =	Earth potential* at point X meters from anode (volts)

* Note: Potential is additive for all anodes affecting point Vx.

3.3.5 Summary of Earth Potential Gradient Calculations

The following table illustrates design earth potential gradients using a 30 DC ampere vertical anode groundbed. The potential values of the pipeline 'Vx", are given with the anode located 100 ft below the bottom elevation of the pipelines, and for a distance of approximately 316 feet from the anode groundbed (a 300 ft linear distance).

The values are given for a design soil resistivitiy of 1,000 and 1,500 ohm-cm at groundbed depth.

Table 3.3.5

Design Parameters	**Anode Distance from Pipeline 'X' (100 ft)**	**Anode Distance from Pipeline 'X' (316 ft)**
Soil Resistivity (ohm-cm)	**1,000**	**1,000**
Anode Output in amperes	30	30
Active Anode Length in cm (ft)	1158.2 (38 ft)	1158.2 (38 ft)
'X' Horizontal distance from Anode to Structure in cm (ft)	3048 (100 ft)	9632 (316 ft)

Natural Potential (Cu/CuSO4)	0.25	0.25
Estimated P/S potential at Vx in volts	0.77	0.25
Net Potential at Vx in volts = (Vx + Natural Potential)	1.02 V	0.50 V

3.3.6 Anode Groundbed Locations

Cathodic protection of the circulating water PCC pipelines will be achieved utilizing distributed deep anode groundbeds positioned along the pipeline route. Each anode groundbed will be rated at 30 DC amperes.

Table 3.3.5 indicates the calculated voltage potential gradients at a given distance from the anode groundbed. The design soil resistivity at an approximate 150 to 200 foot depth from grade is taken as 1000 ohm-cm.

The design intent is to locate the vertical deep anode groundbeds at or near the beginning and ends of the pipeline where the pipeline enters into the condenser building or cooling towers. The next anode groundbed along the pipeline route(s) will be located on approximate 400 to 600 ft intervals taking into consideration the locations of the instrument / manhole vaults which will require that anode groundbeds to be located in the near vicinity of these structures

It is necessary to position deep anode groundbeds at or near the ends of the pipeline route where they enter into a building, cooling tower structure or near instrument vaults and manholes, due to higher current demand of other underground metallic structures such as the copper grounding system and building / vault reinforcement bars (rebar). These underground metallic structures will "drain" cathodic protection current intended for the PCC pipelines at these locations.

This arrangement will provide an "additive" net potential value of approximately -1.0 volt at the midpoint section of the pipelines from two (2) adjacent anode groundbeds spaced at 600 feet apart. The CP systems are then adjusted to their lowest optimum DC output upon polarization of the pipeline structures.

The CP design will position deep anode groundbeds at or near the following locations:

- Condenser building inlet at units 1 & 2
- Near each of the 4 cooling towers near the valve pits.
- Between each of the 4 cooling towers near the outlet flume for the 144" pipelines.
- At or near each of the instrument vaults

- At or near the east side of the Helper cooling tower for units 1 & 2

3.3.7 Control of Cathodic Protection Current

To achieve maximum control of the distribution of CP current along the entire length of the pipeline, each anode groundbed will be energized with an individual transformer rectifier unit. To minimize the number of rectifier locations that will require AC power to be provided, multi-circuit rectifiers will be used with up to four (4) rectifier circuits being housed in one enclosure.

This arrangement will allow for complete control of cathodic protection current which is important to ensure that over protection of the pre-stressing wires does not occur.

Initially, the anode groundbeds will be adjusted to operate at or near their rated capacities while pipe-to-soil potential measurements are monitored at each of the anode groundbed locations and along the pipeline route. It is expected that the DC output of the anode groundbeds located at the ends of the pipelines and at the instrument / manhole vaults will be significantly reduced after polarization of the PCC pipelines is achieved.

The systems will be adjusted to achieve a balance of protective potential level with the instant off potential at any one location not to exceed -1.0 volts with respect to a Cu/CuSo4 electrode.

3.4 Surface Area and Current Requirement

The minimum CP current requirement for the corrosion protection design has considered the current required for:

1.) Cathodic protection of the PCC Circulating Water Pipelines and,

2.) Current drain (loss) to several underground metallic structures that are electrically continuous with the PCC pipelines, such as copper electrical grounding systems and building reinforcement bars (rebar) etc., and will therefore collect a larger degree of cathodic protection current than required for protection of the PCC pipe.

To account for current drain or loss to these other structures, a design current density is applied to these estimates and expressed as mA/ft^2. These values are included in the overall current requirement for the system design. A contingency factor is typically provided to the current requirement estimates to ensure of sufficient current to cathodically protect the subject structures. An approximate 20% contingency factor has been used in this design where applicable. Appendix B, data table A - D includes a quantified list of structures, their estimated surface areas and/or partial length of the structure considered and location as they contribute to the system design and current drain estimate for design purposes.

In addition, current requirement tests using a temporary impressed current CP system were conducted in front of the condenser building at Units 1 & 2 to determine the current distribution characteristics in this area. This area is very congested with other underground metallic structures such as the copper grounding system, reinforcement bars (rebar) associated with the building and other concrete foundation structures, and other metallic piping structures in the area. The results of these tests are included in Appendix B, data table B.

In accordance with the NACE Standard RP0100-2004, and industry standards the CP design will use the following current densities for various metallic structures that will collect cathodic protection current:

- 0.0001 Amp / ft^2 for PCC Pipe (0.1 mA/ ft^2)
- 3 mA/ ft^2 for carbon steel pipelines.
- 15 mA/ ft^2 for copper ground rods and cable
- 2 mA/ ft^2 of total surface area of storage tank bottoms and steel piling

3.4.1 Current Requirement for Design

The results of the calculated surface area and current requirement estimates for the circulating water supply and return PCC pipelines is approximately 46 DC amperes as outlined in data table A.

The results of the calculated surface areas and current requirement estimates within the Condenser, General Services and Administration Building areas for grounding and foreign structures is approximately 135 DC amperes as outlined in data table B.

The results of the current requirement tests conducted in front of the condenser unit building indicate that approximately 150 DC amperes of current is required in this area to account for current drain (loss) to other metallic structures within this area.

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Data Table D provides information related to miscellaneous structures encountered along the pipeline right of way. This information is provided to illustrate the necessity of providing a higher degree of current density at or near these structures. The design philosophy of installing 30 ampere rated "close coupled" anode groundbeds on approximate 400 to 600 foot intervals along the pipeline ROW will sufficiently account for the current drainage to these structures.

3.4.2 Number of Cathodic Protection Systems

3.4.2.1 CP System No. 1 and 2 – Foreign Structures

The current requirement tests and calculated estimates near the condenser building, general services and administration building areas indicate approximately 135 to 150 DC amperes are required to account for current loss, primarily to the copper grounding system and building and foundation reinforcement bars and other miscellaneous underground metallic structures.

Two (2) impressed current cathodic protection systems will be installed in this area. Each CP system will utilize a dual circuit transformer rectifier unit rated at 32 Volt / 40 Amp each circuit. One (1) deep anode groundbed will be energized by one (1) 40 amp rectifier circuit, for a total of four (4) deep anode groundbeds in this area. The DC negative return cable for each of these circuits will be will be connected to the copper grounding system in this area.

The 40 amp deep anode groundbed will utilize six (6) mixed metal oxide anodes and installed to a depth of 190 feet. The locations of the anode groundbeds are shown sheet 1 and 2 of the cathodic protection drawings along with approximate GPS coordinates.

3.4.2.2 CP System No's. 3 to 8 - Circulating Water PCC Pipelines

A total of five (5) close coupled impressed current cathodic protection systems will be provided for the 60", 72", 84" and 120" circulating water supply and return pipelines. These systems will utilize deep anode groundbeds rated at a DC capacity of 30 amperes and installed to a depth of 170 feet.

CP System No. 3 & 4

CP system no. 3 and 4 will each utilize a dual (2) circuit rectifier unit rated at 30 DC amp / 30 Volt for each circuit. Each rectifier circuit will energize one deep anode groundbed. The DC negative return cable will be connected to the 120" CW rwturn and CW supply pipelines within the manholes.

These systems will protect the 120" circulating water pipelines from the condenser building area to manhole number 2B (4 manholes) near the circulating water pump house.

CP System 5

CP system no 5 will utilize a four (4) circuit rectifier unit with each circuit rated at 30 Amp / 30 Volts DC. Each rectifier circuit will energize one deep anode groundbed. The negative return cable will connect to the PCC pipe inside the instrument manhole vaults associated with unit 2

This system is associated with the 120", 84" and 60" circulating water return pipelines for unit 2 routed to cooling towers 2A and 2B.

CP System No. 6 and 7

CP system no. 6 and 7 are associated with the 120", 84" and 60" circulating water return pipelines for unit 1 routed to cooling towers 1A and 1B. This pipeline is longer than the CW return pipeline for unit 2 and will require three (3) circuit rectifier units rated at 30 Amp / 30 Volt DC. The negative return cable will connect to the PCC pipe inside the instrument manhole vaults associated with unit 1.

CP System No. 8

CP system no. 8 will utilize a dual (2) circuit rectifier unit with each circuit rated at 30 Amp / 30 Volt DC. Each rectifier circuit will energize one deep anode groundbed. The negative return cables will connect to the PCC pipes inside the chemical mixing structure at the circulating water pump house.

This system is associated with 144" circulating water return pipeline routed from cooling towers 1A / 1B and 2A and 2B to the circulating water pump house.

3.5 Anode Current Output and Design Life

Tubular titanium/ MMO anodes with nominal dimensions of 1.25" diameter x 48" long are proposed for the impressed current cathodic protection systems. The surface area of this anode is 1.3 ft^2 (0.12 m^2) The design life of the anode is a function of the output current density as expressed by the following relationship per the manufacturer's data:

$LogL = 3.3 - Log(Id)$

Where:

L = Design Life (25 years)

Id = Anode current density (Amp/m^2)

Therefore: Log Id = 3.3 – Log 25

Id = 3.3 – 1.9 = 1.9

Id = $1.9 \times 10^{1.9}$ = 79.4 amp/m^2

The surface area of the anode is 0.12 m^2.
Maximum current output = 0.12 x 79.4 = 9.53 amps per anode.
This value can be further de-rated to provide a safety margin to avoid overloading of the anode.
This design will use a utilization factor of 80%.

Therefore: 9.53 amps x 0.8 = 7.62 ampere maximum DC output per anode.

A total of 4 anodes are used in each anode groundbed. 4 x 7.62 = 30.5 Amperes.

30.5 A $\geq$ 30 Amp DC Anode groundbed design.

3.5.1 40 Amp DC Anode Groundbed

The 40 DC ampere anode groundbeds will use six (6) MMO anodes of the same dimensions. Therefore 6 x 7.62 = 45.72 > 40 Amp DC anode groundbed design.

3.6 DC Circuit Resistance

The total DC circuit resistance for CP system includes both the anode groundbed resistance and the cable resistance.

Rt = Rg + Rc

Where:

Rt = Total circuit resistance (ohm)

Rg = Groundbed resistance (ohm)

Rc = DC cables resistance (ohm)

The following sections outline each of these resistances:

3.6.1 Groundbed Resistance

3.6.1.1 Deep Anode Groundbed - 30 Amp

The 30 amp deep anode groundbed will consist of (4) individual 1.25" diameter x 48" long MMO anodes installed vertically on 6 foot end-to-end spacing and backfilled with calcined petroleum coke breeze. The anode column will be 44 feet with a total groundbed depth of 170 feet.

The following calculation developed by Dwight is used to determine the resistance to earth of the vertical anode groundbed:

$Rv = 0.159p\ (\ln(8L) - 1)$

Where:

Rv = Anode-to-Earth resistance (in ohms)

p = Soil resistivity (1,000 ohm-cm)

L = Length of anode including cokebreeze column – 1341 cm (44 ft)

d = diameter of cokebreeze column 15.24 cm (0.5 ft)

Rv = 0.66 ohms

3.6.1.2 Deep Anode Groundbed - 40 Amp

Where:

Rv = Anode-to-Earth resistance (in ohms)

p = Soil resistivity (1,000 ohm-cm)

L = Length of anode including cokebreeze column – 1951 cm (64 ft)

d = diameter of cokebreeze column 15.24 cm (0.5 ft)

Rv = 0.48 ohms

3.6.2 Cable Resistance

One (1) positive and one (1) negative DC header cable is used for each rectifier circuit.

The resistance of each of the positive and negative DC cabling associated with the rectifier circuits is summarized in the following table.

Table 3.6.2

CP System No. / CCT (No.)	Cable ID	Cable Size (AWG)	From	To	Length (ft)	Ohm/ft	Total Ohm
1 / cct-1	Negative Cable	4	TR-1	2/0 or 4/0 awg Ground	75	0.00025	0.02
1/ cct-1	Positive Cable	4	TR-1	Anode Junction Box CP1-1	150	0.00025	0.04
1 / cct-2	Negative Cable	4	TR-1	2/0 or 4/0 awg Ground	75	0.00025	0.02
1/ cct-2	Positive Cable	4	TR-1	Anode Junction Box CP1-2	150	0.00025	0.04
2/ cct-1	Negative Cable	4	TR-2	PCC Pipe in Manhole	75	0.00025	0.02
2/ cct-1	Positive Cable	4	TR-2	Anode Junction Box CP2-1	150	0.00025	0.04
2/ cct-2	Negative Cable	4	TR-2	PCC Pipe in Manhole	75	0.00025	0.02
2/ cct-2	Positive Cable	4	TR-2	Anode Junction Box CP2-2	150	0.00025	0.04
3/ cct-1	Negative Cable	4	TR-3	PCC Pipe in Manhole	350	0.00025	0.09
3/ cct-1	Positive Cable	4	TR-3	Anode Junction Box CP3-1	350	0.00025	0.09
3/ cct-2	Negative Cable	4	TR-3	PCC Pipe in Manhole	350	0.00025	0.09
3/ cct-2	Positive Cable	4	TR-3	Anode Junction Box CP3-2	350	0.00025	0.09
4/ cct-1	Negative Cable	4	TR-4	PCC Pipe in Manhole	250	0.00025	0.06
4/ cct-1	Positive Cable	2	TR-4	Anode Junction Box CP4-1	800	0.00016	0.13
4/ cct-2	Negative Cable	4	TR-4	PCC Pipe in Manhole	250	0.00025	0.06
4/ cct-2	Positive Cable	4	TR-4	Anode Junction Box CP4-2	250	0.00025	0.06
5/ cct-1	Negative Cable	4	TR-5	PCC Pipe in Instrument Vault Manhole at BUS Bldg	550	0.00025	0.14
5/ cct-1	Positive Cable	4	TR-5	Anode Junction Box CP5-1	450	0.00025	0.11
5/ cct-2	Negative Cable	4	TR-5	PCC Pipe in Instrument Vault Manhole at BUS Bldg	550	0.00025	0.14
5/ cct-2	Positive Cable	4	TR-5	Anode Junction Box CP5-2	150	0.00025	0.04
5/ cct-3	Negative Cable	4	TR-5	PCC Pipe in Instrument Vault Manhole at cooling tower	150	0.00025	0.04
5/ cct-3	Positive Cable	4	TR-5	Anode Junction Box CP5-3	400	0.00025	0.10
5/ cct-4	Negative Cable	4	TR-5	PCC Pipe in Instrument Vault Manhole at cooling tower	150	0.00025	0.04

5/ cct-4	Positive Cable	2	TR-5	Anode Junction Box CP5-4	900	0.00016	0.14
6/ cct-1	Negative Cable	4	TR-6	PCC Pipe in Instrument Vault Manhole at cooling tower	450	0.00025	0.11
6/ cct-1	Positive Cable	2	TR-6	Anode Junction Box CP6-1	700	0.00016	0.11
6/ cct-2	Negative Cable	4	TR-6	PCC Pipe in Instrument Vault Manhole at cooling tower	450	0.00025	0.11
6/ cct-2	Positive Cable	4	TR-6	Anode Junction Box CP6-2	450	0.00025	0.11
6/ cct-3	Negative Cable	4	TR-6	PCC Pipe in Instrument Vault Manhole at cooling tower	450	0.00025	0.11
6/ cct-3	Positive Cable	4	TR-6	Anode Junction Box CP6-3	100	0.00025	0.03
7/ cct-1	Negative Cable	4	TR-7	PCC Pipe in Instrument Vault Manhole at cooling tower	150	0.00025	0.04
7/ cct-1	Positive Cable	4	TR-7	Anode Junction Box CP7-1	400	0.00025	0.10
7/ cct-2	Negative Cable	4	TR-7	PCC Pipe in Instrument Vault Manhole at cooling tower	150	0.00025	0.04
7/ cct-2	Positive Cable	2	TR-7	Anode Junction Box CP7-2	700	0.00016	0.11
7 / cct-3	Negative Cable	4	TR-7	PCC Pipe in Instrument Vault Manhole at cooling tower	150	0.00025	0.04
7/ cct-3	Positive Cable	2	TR-7	Anode Junction Box CP7-3	1100	0.00016	0.18
8/ cct-1	Negative Cable	4	TR-8	PCC Pipe in Manhole	400	0.00025	0.10
8/ cct-1	Positive Cable	4	TR-8	Anode Junction Box CP8-1	300	0.00025	0.08
8/ cct-2	Negative Cable	4	TR-8	PCC Pipe in Manhole	400	0.00025	0.10
8/ cct-2	Positive Cable	2	TR-8	Anode Junction Box CP8-2	800	0.00016	0.13

* T/R no. 7, circuit number 3 represents the worst case maximum resistance of all circuits for the positive and negative DC cables. Given this value:

The total cable resistance (Rc) is:

Negative cable: 0.04 ohms

Positive cable: 0.18 ohms

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Rc = 0.22 ohms

3.6.3 Total Circuit Resistance

Rt = Rg + Rc

Where:

Rt = Total circuit resistance (ohm)

Rg = Groundbed resistance (ohm)

Rc = DC cables resistance (ohm)

3.6.3.1 30 Amp Anode Groundbed

Rt 0.65 + 0.22 = 0.87 Ohm

3.6.3.2 40 Amp Anode Groundbed

Rt 0.48 + 0.22 = 0.70 Ohm

3.6.4 Transformer Rectifier DC Output Voltage

The DC voltage rating of the transformer rectifier to achieve the desired DC current output is calculated by the following equation:

E = [(It x Rt) + Bemf] x Sf

Where:

E	= DC output voltage requirement (volt)
It	= Total current requirement (amp) 40 or 30 amp
Rt	= Total circuit resistance (ohm) 0.89 or 0.72 ohm
Bemf	= Back emf (2.0 volt)
SF	= Safety Factor (1.1 = 10%)

Therefore:

E_{30} = [(30 x 0.87) + 2] x 1.1 = Say 30 Volts

E_{40} = [(40 x 0.70) + 2] x 1.1 = Say 32 Volts

Transformer rectifier units with a DC output capacity rated at 30 Amp / 30 Volt and 40 Amp / 32 Volts are selected for this system.

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3.6.5 AC Power Requirement

The following calculation has been used to estimate the AC current requirement for the transformer rectifier unit.

Iac = (Idc * Edc) / (Eac * Eff)

Where:
I_{AC} = AC current
E_{AC} = AC voltage (115)
I_{dc} = DC current (30A)
E_{dc} = DC voltage (30 V)
Eff = Efficiency (75 %)
Iac = (30 x 30) / (115 x 0.75) = 10.43 AC Amperes

Multi-circuit rectifier units are utilized for this cathodic protection design. The following table provides information relative to the proposed CP system rectifier and the manufacture's determined AC power requirement.

This information is to be confirmed for the exact rectifier to be supplied for the project prior to sizing the MCC - AC circuit breaker and power cables to the rectifier units.

CP System / Transformer Rectifier No.	DC Rating / (No. of Circuits)	AC Power (Amperes)
1 and 2	40A / 32V (2)	37
3, 4 and 8	30A / 30V (2)	26
5	30A / 30V (4)	52
6 and 7	30A / 30V (3)	39

3.7 Method of Operation

The following section outlines the initial start up and normal operation of the cathodic protection system. The operation of the cathodic protection system(s) must be routinely monitored by a professional corrosion consulting firm to ensure that effective levels of cathodic protection are being maintained to the PCC piping structures and to ensure that the pipe-to-electrolyte (pipe-to-soil) potentials do not exceed over voltage values.

All pipe-to-soil potential measurements recorded will be limited to an "instant off" potential value of -1.0 volt with respect to a copper/ copper sulphate reference electrode (-1.05 V wrt Ag/AgCl electrode).

3.7.1 Pre-Commissioning

The following sequence will be followed to place the cathodic protection system into commission. All information shall be documented.

- Review project drawings for correct installation of the cathodic protection system.
- Conduct continuity loop tests between the positive and negative junction boxes of each rectifier circuit to ensure each circuit is properly wired for both polarity and for proper circuit location.
- Check all cable connections at junction box and other termination points for tightness.
- Ensure all rectifier circuits are adjusted to their minimum setting. Zero DC output.
- Test the incoming AC voltage at the MCC circuit breaker and at the circuit breaker of the rectifier unit to ensure compatibility with the AC voltage rating of the rectifier unit. After the test is complete, turn off the AC power at both of these locations.
- Record "native" off potential measurements at all permanent reference electrode locations and at all test station access holes.
- The cathodic protection systems are now ready to be energized for initial start-up.

3.7.2 Initial Start-Up

After the pre-commissioning work is completed, the CP systems can be individually tested and adjusted as follows. Visit each rectifier individually and conduct the following tests

- Ensure each circuit of the rectifier unit is adjusted to it's minimum DC output by turning the controlling potentiometer on the circuit board fully counter-clockwise. The system is then adjusted to zero DC output.

- Turn on the AC voltage at the MCC, and then at the rectifier circuit breaker. Each circuit of the rectifier unit (2 cct's, 3 cct's, or 4 cct's) will be energized in the following steps:

- Slowly adjust the current potentiometer on the circuit board in a clockwise direction until 50% DC current output is achieved. Let the system operate at this output for 5 minutes. Visually inspect the rectifier for any signs of malfunction such as burning, an unusually load buzzing or humming sound and for overly heated components.

- Slowly increase the potentiometer until approximately 100% DC current output is achieve ensuring that the DC voltage rating of the unit is not exceeded. Record the DC current and DC voltage values for documentation.

- Reduce the DC current output to approximately 75% of the rated capacity of the rectifier circuit. There are 30 amp and 40 amp rectifier circuits.

- Visit the corresponding anode junction box circuit and record the DC current output of each anode circuit using a portable DC ammeter and / or by measuring the current output at the 0.01 ohm shunt installed for each anode circuit.

- Leave the system operating at this DC output and visit the next CP system rectifier unit for initial start up and continue until all eight (8) cathodic protection systems are placed into initial commission. Leave these systems in operation for a period of 12 to 24 hours and conduct final commissioning procedures as described in section 3.7.3 below.

3.7.3 Commissioning

With all CP systems placed into initial commissioning as outlined in section 3.7.2, the following final commissioning sequence shall be followed:

- The rectifiers will be provided with a terminal block on the front panel to allow synchronized current interruption of each circuit within a common rectifier unit. Portable synchronized current interrupters (GPS) will be used to connect to this terminal block at each of the eight (8) CP system rectifiers. This arrangement will be used to conduct "instant off" potential data required to adjust the system to optimum performance levels.

- Set the timing "on/off" cycle of each of the (8) current interrupters to achieve a cycle of 8 seconds "On" and 2 seconds "Off' in accordance with the manufacture's instructions.

- Turn on the interrupter and synchronize each of the current interrupters in accordance with the manufacture's instructions.

- Connect the synchronized interrupter to the terminal block of each rectifier unit and check to observe that the rectifier unit is cycling in an "on/off cycle of 8 seconds / 2 seconds.

- With all eight (8) CP systems cycling as described above, begin recording On/Instant Off pipe-to-soil potential measurements at each of the same locations where native potentials were recorded during the pre-commissioning tests. Document the On / Instant Off potential measurements for immediate review.

- Immediately after recording the potential measurements at all permanent reference electrode locations and at all portable electrode / test access hole locations, review the potential data and determine if any "Instant Off' potential value is **"more negative"** than -1.0 mV to a copper-copper sulphate of -1.05 mV to a silver-silver chloride electrode.

- If the instant off potential measurement at any one location exceeds the above values, it will be necessary to reduce the current output of the closest cathodic protection circuit of circuits to that reference electrode location.

- The ideal cathodic protection adjustment will be to achieve a polarized (instant off) potential value at ranging between -800 to -900 mV with respect to a silver chloride reference electrode (-850 to -950 mV to Cu/CuSo4 electrode).

- The maximum allowable instant off potential will be -1.05 mV to a silver/silver chloride reference electrode (-1.0 mV to Cu/CuSo4 electrode).

- The pipe-to-soil potential measurement values shall also be reviewed to ensure criterion for cathodic protection has been achieved as outlined in section 3.7.4 below. If necessary, the current output of the closest rectifier circuit nearest to the low potential area should be increased and the reference electrode location retested to determine if criterion for protection has been achieved.

- Record the final DC current and voltage output of each cathodic protection circuit in each rectifier unit.

- Record the final DC current output at each anode junction box for each cathodic protection circuit.

3.7.4 Criteria for Cathodic Protection

NACE International Standard RPO100-2004 Standard Recommended Practice – Cathodic Protection of Prestressed Concrete Cylinder Pipelines will be used to determine criteria for cathodic protection of the PCC pipelines.

The following criterion is taken from Section 4 Cathodic Protection Criteria:

- Section 4.1.1

  A minimum of 100 millivolt cathodic polarization between the structure surface and a stable reference electrode contacting the electrolyte. The formation or decay of polarization can be measured to satisfy this criterion.

- Section 4.1.2

  A maximum polarized potential of -1.0 Volt with respect to a Cu/Cuso4 electrode.

3.7.5 Final Commissioning Adjustments

After two months operation, the cathodic protection systems shall be retested in accordance with the procedures outlined in section 3.7.3.

The results of the data shall be reviewed in conjunction with the commissioning data to determine that:

1. Cathodic protection criteria has been achieved at all locations tested.

2. Potential measurements recorded at any location do not exceed a polarized potential -1.0 mV with respect to a Cu/Cuso4 electrode.

Final adjustments are to be made as required, and the results of the final tests along with a commissioning report shall be submitted to the owner to be used as "base value' data from which to operate the cathodic protection systems.

3.7.6 Routine Monitoring

The cathodic protection system(s) should be monitored by a professional corrosion consulting company on a bi-annual basis to ensure proper operation of the systems.

Section 3.7.3 should be used as a basis from which to conduct the tests.

APPENDIX A

CORROSION OF PRESTRESSED CONCRETE CYLINDER PIPE

APPENDIX A
CORROSION of PCCP

Concrete normally provides the embedded steel in PCCP with excellent corrosion protection. The highly alkaline environment in concrete results in formation of a tightly adhering film which passivates the steel and protects it from corrosion. In addition, concrete can be proportioned to have a low permeability which minimizes the penetration of corrosion inducing substances. Low permeability also increases the electrical resistivity of the concrete which impedes the flow of electrochemical corrosion currents. Because of these inherent protective qualities of the concrete, corrosion rates of embedded steel are normally minimal. Corrosion can, however, occur under certain circumstances.

The mechanisms of corrosion are of two basic types, galvanic and electrolytic. Galvanic corrosion is the most common and is self generated resulting from differences in potentials along the metallic surface. These differences in potential can result from the coupling of dissimilar metals or they can result from variation in physical or chemical conditions which exist on the surface of a single metal. These variations include non-homogeneity of the metal due to cold working, intergranular impurities, wire notches or splits, or other differences. Current from the corroding metal (anode) flows into the electrolyte, to the non-corroding metal (cathode) then back through the metallic connection between the two. This constitutes a galvanic corrosion cell.

In the case of PCCP, the corrosion cells are caused by variations in the conditions at the surface of the embedded steel. The environment surrounding the steel becomes non-uniform through one or more of the following mechanisms:

- Cracks in the mortar.
- High permeability of the mortar.
- Insufficient thickness of mortar cover.
- Variations or voids in contact between the steel and the mortar.
- Carbonation of the mortar coating.
- Chloride ion contamination of the mortar.
- Delamination of the mortar coating from the steel.

Where cracks or delaminations occur in the mortar coating, the continuity of the alkaline mortar is disrupted and varying portions of the steel are exposed to water and oxygen at a lower pH. The resulting galvanic cell can develop high rates of corrosion depending on the size of the anodic and cathodic areas and the availability of oxygen. Severe corrosion will occur at the interface between the portion of the steel still protected by the mortar coating and that portion which is exposed.

Corrosion of embedded steel can also occur in undamaged concrete. It is well documented that the intrusion of chloride ions in concrete can cause steel corrosion if oxygen and moisture are also available to sustain the necessary reaction.

The products formed during the corrosion process occupy over twice the volume as the original steel. The tensile stresses exerted by the corrosion products which can exceed the tensile fracture limits of the concrete interface have been measured to be as high as 4700 psi.

Chloride ions may be introduced into the concrete in a variety of ways. The AWWA Standards regarding the manufacture of PCCP specify the maximum allowable concentrations of chloride ions. Therefore, if the pipe is manufactured according to AWWA Standards, high concentrations of chloride ions found in PCCP most likely have diffused into the mature concrete by way of ground water. Chlorides can permeate through sound concrete (i.e. cracks are not necessary for chlorides to enter the concrete) and initiate corrosion.

There are presently three theories that explain the effects of chloride ions on embedded steel:

- The Oxide Film Theory - The passive film is a diffusion barrier of reaction products that separates the metal from its environment. This theory postulates that chlorides penetrate the protective oxide film through pores or defects in the film more easily than other ions.

- The Adsorption Theory - The passive film is a layer of oxygen adsorbed on the metal surface. Chloride ions are adsorbed on the metal surface in competition with dissolved oxygen or hydroxyl ions. The chloride ion permeates the hydration of the metal ions and thus facilitates the dissolution of the metal.

- The Transitory Complex Theory - Chloride ions compete with hydroxyl ions for ferrous ions produced by corrosion. A soluble complex of ion chloride forms which diffuses away from the anode. The complex eventually breaks down and the chlorides are free to transport more ferrous ions from the anode. Evidence of this process is observed when the concrete with active corrosion is broken open. A light green reaction product is often found near the steel which on exposure to air, turns black and eventually rust red in color.

Carbonation can also cause corrosion of embedded steel in concrete. Carbonation occurs when the concrete reacts with carbon dioxide from the air or water. This reduces the pH of the concrete and corrosion of the embedded steel can occur.

It has been reported that sulfate and carbonate salts can also cause steel in concrete to corrode. However, this has not been well documented. Their low solubility in a high calcium ion environment would tend to reduce their availability. Certain soluble salts such as perchlorates, acetates and salts of other halogens may be corrosive to steel in concrete. Hydrogen sulfide has also been cited as a cause for corrosion.

Electrolytic or stray current corrosion is the result of direct current from outside sources entering and discharging from a metal structure through the electrolyte. Current collecting on PCCP has little effect, but where the current is discharged, corrosion can occur.

The most common form of corrosion in an aqueous medium is electrochemical. An anode where oxidation takes place, an electrical conductor and an aqueous medium must be present. Any metal surface on which corrosion is taking place is a composite of anodes and cathodes connected through the metal.

At the anode, the iron is oxidized to ferrous ions:

$$Fe = Fe^{++} + 2e^-$$

The Fe^{++} is changed to oxides of iron by a number of reactions. These corrosion products occupy a larger volume than the original steel. This increase in volume can crack the surrounding mortar. This cracking allows more contamination to reach the surface of the prestressing wire thereby further accelerating the rate of corrosion.

At the cathode, a reduction reaction takes place. Assuming an adequate supply of oxygen exists, the cathodic reaction is the reduction of oxygen to form hydroxyl ions:

$$2\ H_2O + O_2 + 4e^- = 4OH^-$$

In PCCP, one or two types of corrosion rate controlling mechanisms normally dominate. One is cathodic diffusion, where the rate of oxygen diffusion through the concrete determines the rate of corrosion. The other type of controlling mechanism involves the development of a high resistance path. When steel corrodes in concrete, the anodic and cathodic areas may be several feet away; therefore, the resistance of the concrete may control the rate of reaction.

Moisture has a significant effect on the resistivity of the concrete. Studies show that the resistivity can change a factor of 1000 between wet and dry conditions.

Although the availability of oxygen is one of the controlling factors for corrosion of steel, little quantitative information is available on its effect in concrete. Obviously, the greater the concrete cover, the less oxygen ingressing to the level of the embedded steel, but the effect does not appear to be linear. The rate of oxygen diffusion through concrete is also affected by the extent to which the concrete is saturated with water. A number of investigations indicate that if the steel passivity is destroyed, conditions will be conducive to the corrosion of embedded steel in those parts of a concrete pipe that are exposed to periods of intermittent wetting and drying. Investigations also indicate that, although chlorides are present, the rate of steel corrosion will be very low if the concrete is continually water saturated. In wet concrete, dissolved oxygen will be diffusing in solution, while in a partly dry concrete, the diffusion of gaseous oxygen is much faster. For oxygen to be consumed in a cathodic reaction, the oxygen must be in a dissolved state.

The effect of salt on the corrosion rate of embedded steel in concrete has been demonstrated by Griffin and Henry. Corrosion increased as the sodium chloride concentration increased until a maximum was reached. Beyond this point, the rate of corrosion decreased despite the increased chloride ion concentration. This is attributed to the reduced solubility and diffusivity of oxygen and therefore the availability of oxygen to sustain the corrosion process.

The corrosion rate of iron is reduced as the pH increases. Since concrete has a pH higher than 12.5, it is usually an excellent medium for protecting steel in concrete.

Several different types of corrosion activity have been observed on embedded steel in concrete. Each of these are briefly described below:

- Pitting Corrosion - This is a localized type of attack with the rate of corrosion being greater at some areas than others. This type of corrosion is especially significant on PCCP. Pitting corrosion can lead to a decrease in cross sectional area of the prestressing wire which could lead to a fracture.

- Stray Current Corrosion - Stray DC currents are those that follow paths other than the intended circuit. They can greatly accelerate the corrosion of the embedded steel. The most common sources are electric railways and cathodic protection systems. At the point that the DC current leaves the steel, rapid rates of corrosion can occur.

- Stress Corrosion - Stress corrosion is defined as the process in which the damage caused by stress and corrosion acting together exceeds that produced when they act separately. In stressed steel, a small imperfection caused by corrosion can lead to serious loss in tensile strength as the corrosion continues.

- Hydrogen Embrittlement - In this case, hydrogen is absorbed in the steel causing a loss of ductility and cracking.

PCCP has consistently provided excellent service when properly installed in most environments. In some environments, precautionary measures may be necessary to ensure pipe integrity. These environments or conditions include the following:

- Adverse Soil Conditions
- Surrounding Structures

Experience has shown that many soils have little effect on PCCP. Still, there are soil conditions that do effect the life of the pipe material. These adverse conditions are as follows:

- High Chloride Concentrations - As previously discussed, the breakdown of the passive film on the embedded steel and subsequent steel corrosion can occur in sound concrete if chlorides are present at the steel surface. Chloride ions generally migrate to the surface of the steel by way of ground water.

- High Sulfate Concentrations - Naturally occurring sulfates of sodium, potassium, calcium or magnesium are sometimes found in soil or dissolved in ground water. These sulfates have been known to chemically attack concrete. The sulfates react with the calcium aluminate hydrates to form sulfurluminates. This attack has been most common in partially buried pipe where capillary action may build up high sulfate concentrations at the ground level.

- Acid Conditions - Acid soils are more conductive to corrosion of corrosion ferrous metals than alkaline soils. Acid soil would effect cracked or broken concrete pipe where the embedded steel is exposed to the soil.

- Low Resistivity Soils - Resistivity is a common parameter for evaluating the corrosiveness of the soil. Resistivity is the inverse of conductivity and is measured in units of ohm-centimeters. Corrosivity is often an inverse function of resistivity with low resistivity soils usually more corrosive than high resistivity soils. Resistivity is also related to concentration of salts, with a low resistivity indicating high levels of salts.

APPENDIX B

DATA TABLES

TABLE A

CIRCULATING WATER PIPELINES

SURFACE AREA AND CURRENT REQUIREMENT FOR PPC PIPELINES

Project Name	CATHODIC PROTECTION OF CIRCULATING WATER PIPELINES
Client	INTERMOUNTAIN POWER SERVICE CORPORATION
Date	Oct-05

Design Parameters

Current Requirement in Amps = (Current Density) * (Surface Area) * (Safety Factor)

Current Density	0.0001	Amp / ft^2
Surface Area	π*D*L	ft^2
Safety Factor	20	%

Pipeline	Diameter		Length	Surface Area	CP Current		
ID	Inch	(ft)	(ft)	ft^2	(amp)		Comment
114" CWR-U1	114	9.5	120	3581.42	0.430		At Bldg entrance N.15340 to Pipe Corridor
114" CWS-U1	114	9.5	135	4029.09	0.483		At Bldg entrance N.15340 to Pipe Corridor
114" CWR-U2	114	9.5	150	4476.77	0.537		At Bldg entrance N.15340 to Pipe Corridor
114" CWS-U2	114	9.5	165	4924.45	0.591		At Bldg entrance N.15340 to Pipe Corridor
84" CWR-U1	84	7	120	2638.94	0.317		At Bldg entrance N.15340 to Pipe Corridor
84" CWS-U1	84	7	135	2968.81	0.356		At Bldg entrance N.15340 to Pipe Corridor
84" CWR-U2	84	7	150	3298.67	0.396		At Bldg entrance N.15340 to Pipe Corridor
84" CWS-U2	84	7	165	3628.54	0.435		At Bldg entrance N.15340 to Pipe Corridor
120" CWR-U1	120	10	1430	44924.77	5.391		At Condenser Bldg Manhole to Manholes at 2b
120" CWS-U1	120	10	1488	46746.90	5.610		At Condenser Bldg Manhole to Manholes at 2b
120" CWR-U2	120	10	1791	56265.92	6.752		At Condenser Bldg Manhole to Manholes at 2b
120" CWS-U2	120	10	1823	57271.23	6.873		At Condenser Bldg Manhole to Manholes at 2b
120" CWR-U1	120	10	490	15393.80	1.847		Manholes at 2b to pump bldg and 84" reducer
120" CWS-U1	120	10	290	9110.62	1.093		Manholes at 2b to pump bldg and 84" reducer
120" CWR-U2	120	10	480	15079.64	1.810		Manholes at 2b to pump bldg and 84" reducer
120" CWS-U2	120	10	290	9110.62	1.093		Manholes at 2b to pump bldg and 84" reducer
84" CWR-U1	84	7	545	11985.18	1.438		From 120"/84" Reducer to Colling Tower 1A/1B
84" CWR-U2	84	7	560	12315.04	1.478		From 120"/84" Reducer to Colling Tower 2A/2B
72" CWR-U1	72	6	100	1884.96	0.226		From 120"/72" Reducer to Pump House Tie-in
72" CWR-U2	72	6	200	3769.91	0.452		From 120"/72" Reducer to Pump House Tie-in
60" CWR-U1	60	5	1021	16037.83	1.925		60" Helper Cooling Tower Pipeline
60" CWR-U2	60	5	740	11623.89	1.395		60" Helper Cooling Tower Pipeline
144" CWR-U1	144	12	555	20923.01	2.511		144" CWR from Cooling Tower 1A/1B to Pump House
144" CWR-U2	144	12	555	20923.01	2.511		144" CWR from Cooling Tower 2A/2B to Pump House
				382,913.02	**45.950**		

TABLE B

CIRCULATING WATER PIPELINES

ESTIMATED SA AND CURRENT REQUIREMENT @ CONDENSER UNIT, GEN. SERVICES & ADMIN. AREAS

Project Name	**CATHODIC PROTECTION OF CIRCULATING WATER PIPELINES**
Client	**INTERMOUNTAIN POWER SERVICE CORPORATION**
Date	**Oct-05**

Design Parameters Copper Grounding				**Reference Drawings:**
Current Requirement in Amps = (Surface Area) * (Current Density) /1000				9255-1BSU-E5011A
	Current Density	**15**	**mA / ft^2**	9255-9STU-S3312
	Surface Area	**π*D*L**	**ft^2**	9255-2BSU-E5011A
	Safety Factor	**20**	**%**	9255-9STU-S3311
				9255-8BSU-E5401A

I.	**Grounding @ Unit 2**	**Diameter**		**Length**	**Surface Area**	**CP Current**		
		Inch	**(ft)**	**(ft)**	**ft^2**	**(amp)**		**Comment**
	500 MCM	1.24	0.1033333	1130	366.83	6.603		Condenser Bldg to Admin Bldg
	2/0 AWG	0.42	0.035	605	66.52	1.197		
	Grd Rod .75" x 20ft	0.75	0.063	200	39.27	0.707		10 ground rods
					472.63	**8.51**		

II.	**Grounding Under Unit 2 Bldg +45 ft (N15340 to 15385)**	**Diameter**		**Length**	**Surface Area**	**CP Current**		
		Inch	**(ft)**	**(ft)**	**ft^2**	**(amp)**		**Comment**
	500 MCM	1.24	0.1033333	1180	383.06	6.895		Under Condenser Bldg at Unit 2
	Grd Rod .75" x 20ft	0.75	0.063	60	11.78	0.212		3 ground rods
	Foundation Rebar					25.000		Estimate 25 amperes Building and misc. outside foundations
					394.85	**32.11**		

III.	**Grounding @ Unit 1**	**Diameter**		**Length**	**Surface Area**	**CP Current**		
		Inch	**(ft)**	**(ft)**	**ft^2**	**(amp)**		**Comment**
	500 MCM	1.24	0.1033333	1130	366.83	6.603		Condenser Bldg to Admin Bldg
	2/0 AWG	0.42	0.035	605	66.52	1.197		
	Grd Rod .75" x 20ft	0.75	0.063	200	39.27	**0.71**		10 ground rods
					472.63	**8.51**		

IV.	**Grounding Under Unit 1 Bldg +45 ft (N15340 to 15385)**	**Diameter**		**Length**	**Surface Area**	**CP Current**		
		Inch	**(ft)**	**(ft)**	**ft^2**	**(amp)**		**Comment**
	500 MCM	1.24	0.1033333	1180	383.06	6.895		Under Condenser Bldg at Unit 2
	Grd Rod .75" x 20ft	0.75	0.063	60	11.78	0.212		3 ground rods
	Foundation Rebar					25.000		Estimate 25 amperes
					394.85	**32.11**		
V.	**Grounding @ Gen. Services Bldg**	**Diameter**		**Length**	**Surface Area**	**CP Current**		
		Inch	**(ft)**	**(ft)**	**ft^2**	**(amp)**		**Comment**
	4/0 AWG	0.53	0.044	330	45.79	0.824		
	Grd Rod .75" x 20ft	0.75	0.063	80	15.71	0.283		4 ground rods
					61.50	**1.11**		
VI.	**Grounding @ Administration Bldg**	**Diameter**		**Length**	**Surface Area**	**CP Current**		
		Inch	**(ft)**	**(ft)**	**ft^2**	**(amp)**		**Comment**
	4/0 AWG	0.53	0.044	200	27.75	0.500		
	Grd Rod .75" x 20ft	0.75	0.063	60	11.78	0.212		3 ground rods
					39.53	**0.71**		
VII.	**Condensate Storgage Tanks**							
	Design Parameters Steel Tank Bottom							
	Current Requirement in Amps = (Surface Area) * (Current Density) /1000							
		Current Density		**3**	**mA / ft^2**			
		Surface Area		**$\pi * r^2$**	**ft^2**			
		Safety Factor		**20**	**%**			Safety factor for reinforced foundation
	Structure	**Diameter**			**Surface Area**	**CP Current**		
	ID	**(ft)**	**radius (ft)**		**ft^2**	**(amp)**		**Comment**
	Unit 1 Condensate Tank	45	22.5		1590.43	5.726		
	Unit 2 Condensate Tank	45	22.5		1590.43	5.726		
					3,180.86	**11.45**		

VIII.	Steel CW Pipes under Condenser Bldg							
	Design Parameters: Steel Circulating Water Pipelines Under Building							
	Current Requirement in Amps = (Surface Area) * (Current Density) /1000							
		Current Density		3	mA / ft^2			
		Surface Area		π*D*L	ft^2			
		Safety Factor		20	%			
	Diameter		Length		Surface Area	CP Current		
	Inch	(ft)	(ft)		ft^2	(amp)	Comment	
	84	7	50		1099.56	3.958		Steel 84" CWR-U1x 50 ft length
	84	7	50		1099.56	3.958		Steel 84" CWR-U2x 50 ft length
	144	12	50		1884.96	6.786		Steel 144" CWR-U1x 50 ft length
	144	12	50		1884.96	6.786		Steel 144" CWR-U2x 50 ft length
					5969.03	**21.49**		
IX.	Steel Piles - Pre-construction							
NOTE:Steel piles used during construction of the building. There are no records of the piles being removed and therefore are included in the current requirement estimates. Estimate 14 foot pile depth and 42 sq. ft surface area per 1.3 linear foot measurement								
Design Parameters								
Current Requirement in Amps = (Surface Area) * (Current Density) /1000								
	Current Density		3	mA / ft^2				
	Surface Area		42ft^2 / 1.3 Lin. Ft	ft^2				
	Safety Factor		None	%				
Structure	Length				Surface Area	CP Current		
ID	Qty	1.3 lin. ft Sections			ft^2 /1.3 Lin ft	(amp)	Comment	
Steel Piles	154	200 total lin. Ft			42.00	**19.40**	Drawing No .9255-9STU- S3312 @ E16273 & N15260	
						19.40		
Total Estimated Current Requirement Sections I to IX:					Total =	135.4 Amp		

IP12_003715

Table C

PCC CIRCULATING WATER PIPELINES

CURRENT REQUIREMENT TEST AT CONDENSER BUILDING

Project Name	CATHODIC PROTECTION OF PCC CIRCULATING WATER PIPELINES
Client	INTERMOUNTAIN POWER SERVICE CORPORATION
Date	Oct-05

NOTE: The area at the condenser unit building is very congested with other underground metallic structures such as electrical grounding cables, reinforced foundations, above grade storage tanks etc. These structures will collect cathodic protection current intended for the circulating water pipelines and must be accounted for in the design of the CP system.
The intent of the test is to observe the current distribution and shift in potential measurement characteristics with a temporary test impressed current CP system installed in the vicinity of the PCC pipes at the condense building for unit 1 and 2.

Test 1
Anode Groundbed: 18 steel rods (5/8" x 4ft) energized by portable DC welder
DC Volts: 28
DC Amps: 13A begin to 8A end of test
Current Interruption Cycle: On 8 sec. / Off 2 sec.

Negative cable connection was made to the CW Supply and Return pipelines (bonded together) at Unit 1 Manholes. Since the PCC pipes are electrically discontinuous at this time, the test is conclusive for only one 16 foot section of CWS pipe and one 16 foot section of CWR pipe for unit 1 pipes.

Location	On (-mV) (10:00 AM) @ 13A	Off (-mV) (10:00 AM) @ 13A	On (-mV) (3:00 PM) @ 8A	Off (-mV) (3:00 PM) @ 8A	Comment
Condensate Tank Unit 2	269	269	278	278	
CWS-U2 at manhole	249	245	242	238	
CWR-U2 at manhole	145	141	255	252	
Cu ground at Unit 1 345KV - C phase pole	167	155	204	195	
FH #53	355	405*	385	440*	* = Interference (Hydrant isolated due to plastic water pipe)
Condensate Tank Unit 1	727	405	774	470	
CWS-U1at manhole	602	365	652	403	
CWR-U1at manhole	440	370	426	354	
Light pole IAPC-LPL-001	-	-	-	-	

IP12_003716

Test 2						
Anode Groundbed: 18 steel rods (5/8" x 4ft) energized by portable DC welder						
DC Volts: 28						
DC Amps: 13.5A begin to 9.5A end of test						
Current Interruption Cycle:		**On 8 sec. / Off 2 sec.**				

Negative cable connection was made to the CW Supply and Return pipelines (bonded together) at Unit 2 Manholes. Since the PCC pipes are electrically discontinuous at this time, the test is conclusive for only one 16 foot section of CWS pipe and one 16 foot section of CWR pipe for unit 2 pipes.

Location	On (-mV) (10:00 AM) @ 13.5A	Off (-mV) (10:00 AM)	On (-mV) (4:00 PM) @ 9.5A	Off (-mV) (4:00 PM)	Comment
Condensate Tank Unit 2	819	404	741	445	
CWS-U2 at manhole	732	401	643	390	
CWR-U2 at manhole	438	346	430	363	
Cu ground at Unit 1 345KV -	183	162	200	192	
FH #53	357	423*	380	435*	* = Interference (Hydrant isolated due to plastic water pipe)
Condensate Tank Unit 1	281	281	287	287	
CWS-U1at manhole	232	232	249	249	
CWR-U1at manhole	256	256	249	249	
Light pole IAPC-LPL-001	373	354	359	359	

Test 3 (Depolarize Test)						
Anode Groundbed: 18 steel rods (5/8" x 4ft) energized by portable DC welder						
DC Volts: 28						
DC Amps: 13A begin to 8.1A end of test						
Current Interruption Cycle:		**On 8 sec. / Off 2 sec.**				

Negative cable connection was made to the CW Supply and Return pipelines (bonded together) at Unit 2 Manholes. Since the PCC pipes are electrically discontinuous at this time, the test is conclusive for only one 16 foot section of CWS pipe and one 16 foot section of CWR pipe for unit 2 pipes.

Location	On (-mV) (3:00 PM) @ 8.1A	Off ^{1}(-mV) (3:00 PM)	Off^2 (-mV) (3:45 PM)	Δ -mV Off^1 - Off^2	Comment
Condensate Tank Unit 2	684	427	255	172	= -172 mV polarization of tank
CWS-U2 at manhole	573	372	229	143	= -143 mV polarization of one 16 ft PCC joint
CWR-U2 at manhole	392	338	237	101	= -101 mV polarization of one 16 ft PCC joint
Cu ground at Unit 1 345KV -	190	184	-		
FH #53	383	430*	-		* = Interference (Hydrant isolated due to plastic water pipe)
Condensate Tank Unit 1	280	280	-		
CWS-U1at manhole	250	250	-		
CWR-U1at manhole	244	244	-		
Light pole IAPC-LPL-001	380	372	-		

CONCLUSIONS

The results of the tests reverify that the PCC pipelines are electrically discontinuous within themselves and between themselves.

The tests indicate that CP current will collect on other underground metallic structures in the vicinity of the circulating water pipelines.

The tests indicate that the circulating water PCC pipelines will readily polarize and meet criteria for cathodic protection with the application of CP current.

It is not possible to measure the current collected to each metallic structures during the tests due to the many parallel return paths of the test current. To estimate current distribution of the tests, assume that 60% of the test current was collecting on other underground structures and that an average of 8 amperes of current was discharged to the 2 x 16 foot sections of PCC pipe where the negative connection was made to the structures during the tests. The current collecting on other structures is then 4.8 amperes per 16 ft linear feet along the length of the pipeline. The PCC circulating water pipelines are routed in a congested area from the condenser building to the administration building, with the majority of the congestion being in front of the condenser unit building over a length of 500 ft, and this is the main area of concern.
500 ft divided by 16 ft PCC joints = 31 lengths of pipe.

Assuming 4.8 amps per 16 linear foot of pipeline was lost to other strtuctures during the tests. Use 4.8 amps x 31 joints = 149 DC amperes for estimated current within this area.

This current requirement value is compared to the current requirement values as estimated by the actual calculated surface areas and applied current densities of the various "other" metallic structures considered in the design, which will collect cathodic protection current in this area. Table B indicates this value is approximately 135 DC Amperes. The greater of these two values (150 Amperes) will be used for the current requirement within the condenser building and administration building area.

TABLE D

SURFACE AREA AND CURRENT REQUIREMENT ESTIMATES MISCELLANEOUS STRUCTURES

Project Name	CATHODIC PROTECTION OF CIRCULATING WATER PIPELINES
Client	INTERMOUNTAIN POWER SERVICE CORPORATION
Date	Oct-05

NOTE: The majority of piping structures in the vicinity and parallel to the circulating water pipelines are non-metallic.

Design Parameters

Current Requirement in Amps = (Surface Area) * (Current Density) /1000

Parameter	Value	Unit	Comment
Current Density	3	mA / ft^2	Steel Structures
Current Density	15	mA / ft^2	Copper Grounding
Surface Area	π*D*L	ft^2	
Safety Factor	20	%	

I. Other Pipelines

Structure ID	Diameter Inch	Diameter (ft)	Length (ft)	Surface Area ft^2		CP Current (amp)	Comment
15" RCP	15	1.25	350	1374.45		4.948	Drawing 9255-9STU-S3311
9HRD	30	2.5	100	785.40		2.827	Drawing 9255-9STU-S3311
				2,159.84		**7.78**	

II. Concrete Manholes

Structure ID	Diameter Inch	Diameter (ft)	Length (ft)*	Surface Area ft^2	QTY	CP Current (amp)	Comment
CW Manholes							
Avg: 10' L x 10' W x 15.5' H							
#6 Rebar - Foundation (*241 ft of rebar / Manhole)	0.75	0.0625	241	47.32	8.00	1.136	8 x CW manholes
2 x 2/0 AWG Grounding	0.42	0.035	420	46.18	8.00	5.542	8 x CW manholes
Assume 100' each direction						**6.68**	

III. Instrument Vaults

Structure ID	Diameter Inch	Diameter (ft)	Length (ft)*	Surface Area ft^2	QTY	CP Current (amp)	Comment
30' L x 8' W x 15' H							
#6 Rebar - Foundation (*1770 ft of rebar / instrument vault)	0.75	0.0625	1770	347.54	4.00	4.170	
2 x 2/0 AWG Grounding	0.42	0.035	460	50.58	4.00	3.035	
Assume 100' each direction							
						7.21	

IV. Duct Banks

Structure ID	Diameter Inch	Diameter (ft)	Length (ft)*	Surface Area ft^2	QTY	CP Current (amp)	Comment
Avg. for 10 Linear ft @							
10' L x 4' W x 6' H duct bank							
#6 Rebar - Foundation (*240 ft of rebar / 10 ft of Duct bank)	0.75	0.0625	240	47.12	4.00	0.565	Current estimated for 10 linear ft of duct bank
2 x 2/0 AWG Grounding (20 ft of grounding cable / 10 LF of duct bank)	0.42	0.035	20	2.20	4.00	0.132	Current estimated for 10 linear ft of duct bank
						0.697	**Per 10 Linear Feet**

V. Cooling Tower Basin (At 144" Pipeline)

Structure ID	Diameter Inch	Diameter (ft)	Length (ft)	Surface Area ft^2	QTY	CP Current (amp)	Comment
Outlet Flume Area							
Assumed Dimensions / Rebar							130 ft L includes 100 ft under tower
130' L x 50' W							
#6 Rebar - Foundation (*1770	0.75	0.0625	10501	2061.87	4.00	24.742	
1 x 2/0 AWG Grounding	0.42	0.035	275	30.24	4.00	1.814	
Grd Rod 0.75" x 20ft	0.75	0.063	20	3.93	5.00	0.295	
						26.851	

IP12_003720

VI. Intake Pump House Reservior (At 144" Pipeline)							
	Diameter		Length	Surface Area		CP Current	
Structure ID	Inch	(ft)	(ft)	ft^2		(amp)	Comment
Intake Pump House Reservior @ Acid Tank							
Assumed Dimensions / Rebar							
75' L x 15' H							
#6 Rebar - Foundation (*1770	0.75	0.0625	2340	459.46		1.654	
1 x 2/0 AWG Grounding	0.42	0.035	150	16.49		0.297	
						1.951	

VII. Cooling Tower Grounding North of Cooling Tower 1A & 1B (At CWR 120", 84" & 60")							
	Diameter		Length	Surface Area		CP Current	
Structure ID	Inch	(ft)	(ft)	ft^2	QTY	(amp)	Comment
1 x 2/0 AWG Grounding	0.42	0.035	360	39.58		0.713	
Grd Rod 0.75" x 20ft	0.75	0.063	20	3.93	8.00	0.471	
						1.184	

VIII. Cooling Tower Grounding South of Cooling Tower 2A & 2B (At CWR 120", 84" & 60")							
	Diameter		Length	Surface Area		CP Current	
Structure ID	Inch	(ft)	(ft)	ft^2	QTY	(amp)	Comment
1 x 2/0 AWG Grounding	0.42	0.035	360	39.58		0.713	
Grd Rod 0.75" x 20ft	0.75	0.063	20	3.93	8.00	0.471	
						1.184	
					Total excluding item IV Duct Banks =	52.87 Amp	

LABORATORY ELECTROLYTE ANALYSIS

CLIENT: IPSI | *ENGINEER: David Kroon*
PROJECT: | *TECHNICIAN: Nancy Jacob*
OFFICE: Houston | *DATE RECEIVED: 06/14/2005*
JOB #: 390025 | *DATE OUT: 06/22/2005*

SAMPLE No.	Borehole No -- Location -- Depth (- from grade)	MOISTURE %	pH	CHLORIDE ppm	SULFIDE ppm	CONDUCTIVITY μmhos	RESISTIVITY ohm-cm	SOIL TYPE	SOIL COLOR
1A	# 1 -- T -- 4.2'	5.30	9.7	19	0	330	3,000	Fine sand & rocks	Gray
1B	# 1 -- M -- 6.8'	5.60	9.9	24	0	390	2,600	Fine sand & rocks	Gray
1C	# 1 -- B -- 9.5'	3.60	9.9	37	0	400	2,500	Fine sand & rocks	Gray
2A	# 2 -- T -- 4.2'	11.00	8.5	950	0	6,000	170	Fine sand & rocks	Gray
2B	# 2 -- M -- 6.8'	5.20	9.4	560	0	2,500	400	Fine sand	Gray
2C	# 2 -- B -- 9.5'	4.40	9.0	960	0	4,000	250	Fine sand & rocks	Gray
3A	# 3 -- T -- 9.1'	7.80	8.9	160	0	1,200	830	Sand, rocks & clay	Gray
3B	# 3 -- M -- 11.8'	9.30	9.3	75	0	660	1,500	Sand, rocks & clay	Gray
3C	# 3 -- B -- 14.4'	9.20	9.6	34	0	660	1,500	Sand, rocks & clay	Gray
4A	# 4 -- T -- 6.9'	6.50	9.4	23	0	290	3,400	Sand & rocks	Gray
4B	# 4 -- M -- 14.0'	8.10	8.8	8	0	160	6,300	Sand, rocks & clay	Gray-brown
4C	# 4 -- M -- 14.0'	19.00	8.9	8	0	220	4,600	Silty loam	Gray-brown
4D	# 4 -- B -- 21.1'	12.00	9.3	9	0	310	3,200	Silt	Gray-brown
5A	# 5 -- T -- 9.1'	25.00	8.9	190	0	1,600	630	Clay	Yellow & light brown
5B	# 5 -- T -- 9.1'	9.90	9	180	0	1,000	1,000	Clay loam	Gray
5C	# 5 -- M -- 11.8'	18.00	8.7	160	0	1,000	1,000	Silty clay loam	Gray-brown
5D	# 5 -- B -- 14.4'	26.00	8.7	140	0	810	1,200	Silty clay loam	Gray-brown
6A	# 6 -- T -- 5.7'	9.20	9.2	72	0	870	1,100	Clay loam & rocks	Gray
6B	# 6 -- M -- 11.5'	11.00	8.9	190	0	1,300	770	Sandy clay loam	Gray-brown

6C	# 6 -- B -- 17.4'	2.90	8.9	110	0	640	1,600	Sand & rocks	Gray
6D	# 6 -- B -- 17.4'	14.00	8.6	240	0	1,400	710	Silty clay loam	Gray-brown
7A	# 7 -- T -- 5.4'	9.20	8.6	78	0	2,000	500	Sandy clay	Gray-brown
7B	# 7 -- M -- 11.3'	3.60	9.1	100	0	530	1,900	Sand & rocks	Gray
7C	# 7 -- B -- 17.1'	23.00	8.8	59	0	560	1,800	Silty clay	Gray-brown
8A	# 8 -- T -- 19.5'	7.00	8.4	540	0	3,300	300	Sandy loam	Gray-brown
8B	# 8 -- M -- 25.4'	3.30	8.8	240	0	1,000	1,000	Sand & rocks	Gray
8C	# 8 -- B -- 31.3'	29.00	8.3	630	0	2,900	340	Clay	Gray-brown
9A	# 9 -- T -- 10.3'	6.80	8.8	290	0	1,600	630	Sandy loam	Gray
9B	# 9 -- T -- 10.3'	7.20	8.8	360	0	1,900	530	Sandy clay loam	Gray
9C	# 9 -- M -- 16.2'	14.00	8.7	240	0	1,800	560	Sandy clay	Gray-brown
9D	# 9 -- M -- 16.2'	12.00	8.8	370	0	2,700	370	Sandy clay loam	Gray
9E	# 9 -- B -- 22.0'	4.40	9.0	54	0	270	3,700	Sand & rocks	Gray
9F	# 9 -- B -- 22.0'	7.70	9.0	130	0	720	1,400	Sandy clay loam	Gray
10A	# 10 -- T -- 10.2'	6.80	9.7	11	0	300	3,300	Sandy loam & clay	Gray-brown
10B	# 10 -- M -- 16.0'	3.60	9.3	6	0	100	10,000	Sand & rocks	Gray
10C	# 10 -- B -- 21.8'	4.00	9.7	7	0	240	4,200	Sand	Gray & brown
11A	# 11 -- T -- 10.3'	6.40	9.4	100	0	760	1,300	Sandy loam & rocks	Gray & brown
11B	# 11 -- M -- 16.2'	3.60	9.4	19	0	280	3,600	Sand & rocks	Gray
11C	# 11 -- B -- 22.0'	11.00	9.3	24	0	460	2,200	Sand & clay	Gray-brown
12A	# 12 -- T -- 10.3'	7.30	9.5	59	0	620	1,600	Sandy loam & rocks	Gray-brown
12B	# 12 -- M -- 16.2'	3.30	9.0	120	0	790	1,300	Sand & rocks	Gray
12C	# 12 -- B -- 22.0'	20.00	8.3	390	0	2,000	500	Sand & clay	Gray-brown
12D	# 12 -- B -- 22.0'	6.60	9	120	0	1,100	910	Silty, sandy loam	Gray-brown

CIRCULATING WATER PIPELINE - SOIL BOREHOLE INFORMATION

DESCRIPTION	NORTH	EAST	GRADE	T.O.P.	Sample 1 @ft	C.L.	Sample 2 @ ft	B.O.P.	Sample 3 @ft	COMMENTS
Bore Hole #1 (60")	18200.85	14986.24	4692.36	4688.16	4.2	4686	6.86	4682.84	9.52	BH to CL is 5' 4"
Bore Hole #2 (60")	15193.26	18281.18	4692.32	4688.16	4.16	4686	6.82	4682.84	9.48	BH to CL is 5'
Bore Hole #3 (84")	14953	17720	4685.74	4676.67	9.07	4674	11.74	4671.33	14.41	BH to CL is 6' 8"
Bore Hole #4 (144")	15272	17662	4687.49	4680.58	6.91	4674	13.99	4666.41	21.08	BH to CL is 9' 5"
Bore Hole #5 (84")	15633	17760	4685.75	4676.67	9.08	4674	11.75	4671.33	14.42	BH to CL is 7'
Bore Hole #6 (120")	15631.64	17327.5	4685.54	4679.85	5.69	4674	11.54	4668.15	17.39	BH to CL is 8'
Bore Hole #7 (120")	14951.5	17283	4685.26	4679.85	5.41	4674	11.26	4668.15	17.11	BH to CL is 8' 7"
Bore Hole #8 (120")	15228.5	17005.88	4684.42	4664.85	19.57	4659	25.42	4653.15	31.27	BH to CL is 8' 7"
Bore Hole #9 (120")	15228.5	16285	4675.19	4664.85	10.34	4659	16.19	4653.15	22.04	BH to CL is 8' 7"
Bore Hole #10 (120")	15228.5	15900	4674.97	4664.85	10.12	4659	15.97	4653.15	21.82	BH to CL is 8' 7"
Bore Hole #11 (120")	15228.5	15682	4675.19	4664.85	10.34	4659	16.19	4653.15	22.04	BH to CL is 8' 7"
Bore Hole #12 (120")	15198.5	15310	4675.19	4664.85	10.34	4659	16.19	4653.15	22.04	BH to CL is 9'

IP12_003724

SOIL RESISTIVITY TEST

Table F

Date: March 21 & 22, 2005
Customer: Intermountain Power
Structure: Prestressed Concrete Cylinder Supply and Return Pipelines
Surveyed By: Corrpro Companies: DDG / HA

Soil Resistivity Test: Wenner 4 - Pin Method

		Average Pipe Depth				
S/N	Location	5 Ft (Ω-Cm)	10 Ft (Ω-Cm)	15 Ft (Ω-Cm)	20 Ft (Ω-Cm)	Comment
1	South east side of cooling tower 2A adjacent road	26,810	30,640	28,725	21,065	Parallel to pipe
2	100 ft west of cooling tower 2B	5,266	5,171	10,628	3,830	Parallel to pipe
3	NE Edge of cooling tower 1A	28,725	21,065	17,235	10,341	Parallel to pipe
4	North east edge of Helper cooling tower	862	1,245	862	958	Parallel to pipe
5	North of cooling tower 1B and return pipeline	6,894	2,107	766	499	Parallel to pipe
6	100 ft west of main gate 20 ft south of road	6,224	5,171	5,171	2,528	Perpendicular to pipe
7	75 ft east of generator bldg between RR tracks and road to switchgear station	1,053	1,721	4,022	2,413	Parallel to pipe

IP12_003725

APPENDIX C

EQUIPMENT SPECIFICATIONS

APPENDIX C

CATHODIC PROTECTION OF PCC CIRCULATING WATER PIPELINES

EQUIPMENT SPECIFICATIONS

1 EQUIPMENT SPECIFICATIONS

The following sections provide the technical specifications for the major components of the cathodic protection system.

1.1 Transformer Rectifier

1.1.1 Applicable Standards

The rectifier and components shall comply with international standards including the latest versions of the following:

NEMA Pub. No. MR-20-1958 Cathodic Reaffirmed by NEMA 1971, 1975.	"Semiconductor Rectifier. Protection Units"
NEMA Standards publication No. 250-1979, including Rev. No. 1 - December 1980	"Enclosures for Electrical Equipment (1000 Volt Max.)
ANSI C 34.2	"Practice and Requirements for Semiconductor Power Rectifiers".
NFPA-70-1984	"National Electrical Code"

1.1.2 General Details

The transformer rectifier units shall be supplying by company who specializes in the manufacture of cathodic protection power supplies. The units shall be designed for continuous 20-years operation. General details on the proposed rectifier unit required for this project are:

Input Power:	115 VAC / single phase / 60 Hz
Number of circuits:	2, 3 and 4
DC Output Voltage:	30 or 32 volt
DC Output Current:	30 or 40 ampere
Mounting:	Frame mounted on concrete foundation or Wall Mounted
Rectification:	SCR - Silicon stack – Full wave bridge
Output Control:	Constant Current Control SCR potentiometer

Protection Rating:	Air cooled, continuous rated NEMA 3R Indoor or outdoor installation
Ambient temperature:	0-45 degree C
Cabinet Construction:	12 Gauge Galvanized Steel
Coating:	3-5 mils of Fusion Bond Powder paint-White
Accessories:	- Common DC Ammeter and Voltmeter with circuit selector switch - Dry Contact Interrupter terminals to Interrupt all DC circuits at the same time With external current interrupter. - AC and DC surge protection - O&M Manual - Spares (Start up fuses supplied, other spares Optional at additional cost) - Identification plate

1.1.2 DC Output Rating

The rectifiers shall be capable of continuous operation at the rated output current and output voltage without damaging any rectifier components. The rectifier shall have multi-circuits with each circuit rated at either 30 or 32 volt and 30 or 40 amperes DC output.

1.1.3 DC Control

Constant "ON" Current, SCR controlled DC output control circuits with provision for voltage control and limiting. Constant current control VIA an instrument panel mounted potentiometer.

1.1.4 Cooling

The rectifiers shall be designing to operate continuously at the rated DC output voltage and current, in ambient temperatures of 45 °C, without damage to the rectifier components. The transformer rectifier shall be air cooled. The air cooled enclosure vents will be screened to avoid ingress of dust and insects.

1.1.5 Input Overload Protection

Protection from overloads on the AC input shall be accomplishing by molded case fully magnetic circuit breakers on the incoming power lines. These circuit breakers shall hold at 100% of load and may trip between 101-125% of rated load and must trip at 125% of rated load and higher. The trip point must be unaffected by changes in ambient temperature. Trip handles of individual pole breakers must be mechanically linking to open all lines when an overload occurs.

1.1.6 Output Overload Protection

Properly sized quick opening semiconductor type fuses shall be provided in the secondary transformer for output overload protection.

1.1.7 Voltage Surge Protection

Voltage surge protection shall be provided AC & DC lightning arresters (AC = Metal oxide varistors; DC = Type L secondary arresters). Also metal oxide varistors (MOVs) shall be provided across output of stack assembly. All varistors shall be sizing to conduct below the peak inverse voltage rating of the diodes used in the stack.

The high joule rate MOV AC & DC arresters shall be supplying with a minimum 500 joules on DC output, 1000 joules on AC input. DC arresters shall be of three-terminal design providing line-to-line and line-to-ground protection.

1.1.8 AC Supply

The unit shall operate from a nominal supply of 115 volt, 1 phase, 60 Hz solidly earthed neutral system. Steady state voltage and frequency variations will be plus 10% or minus 5% for voltage and plus or minus 2% for frequency.

1.1.9 Transformer

The transformer shall be an isolation type with a grounded electrostatic shield between the primary and secondary windings. Dielectric strength of all insulating materials shall not be less than 2,000 volts RMS as tested for one minute when applied between windings and the transformer core.

Magnet wire insulation and layer insulation shall be rating not less than 155 °C. Magnet wire insulation shall not show signs of softening or crazing after 24 hours immersion in any of the following chemicals: Naptha, Toluene, Ethyl Alcohol, Trichloroethylene, Styrene Polyester, Butyl Acetate, mild acids, or Acetone.

Impregnating varnish used shall meet standards for 180 °C. The transformer shall be preheated before vacuum impregnating and baked after the process.

Transformer temperature rise, as measured by thermocouples within the transformer, shall not exceed 40° C above ambient at full load.

The efficiency of the transformer shall be not less than 92%.

The chokes and reactors shall meet the requirements listed for transformers.

The rectifier shall be capable of providing full rated output at 10% below nominal AC input voltage and shall not be damage by line voltages 20% above nominal value.

The unit shall be capable of continuous open circuit operation.

1.1.10 Rectifying Elements

The rectifying elements shall consist of silicon diodes configured as full wave-bridge. The Peak inverse voltage rating of the diodes shall be 300% of the maximum impressed voltage on the device or 400 volts, whichever is greater.

Heat sinks shall be sizing to keep diode junction and case temperatures from exceeding 100 °C with 45 °C ambient temperatures.

1.1.11 Meters

Separate continuous reading voltmeter and ammeter shall be providing for monitoring the rectifier DC output. Minimum meter width shall be 3 1/2 inches round or rectangular with minimum scale length of 2.875 inches. The meter movement shall be pivot and jewel D'Arsonval type. The DC meters shall be installed in a separate end housing of the rectifier. A selector switch will be used to select the appropriate rectifier circuit of the unit.

Meter accuracy shall be a minimum of ± 2% of full scale at 80 °F and shall be temperature-compensated to vary no more than 1% per 10 °F temperature variation.

The ammeter shunt shall be block "SW" type mounted on the front panel for easy access. Current and millivolt ratings shall be clearly stamped on the shunt. Shunt accuracy shall be at least ±1%.

1.1.12 Indicating / Alarm Light

The rectifier shall be providing with an external indicating lights, which shall indicate proper operation or improper operation of the rectifier. The light will be connecting to an electronic circuit, which will cause a red alarm light to indicate failure or low DC output current. A green light will indicate proper operation of the rectifier.

1.1.13 Enclosure

The rectifier enclosure shall be suitable for outdoor environments with 100% humidity and ambient temperature from -50° C to + 45° C.

The rectifier enclosure shall be constructed of galvanized steel with a minimum thickness of 12 gauge. All cabinet hardware including hinges and hasps shall be of stainless steel construction. The cabinet shall be welded construction and conform to Type 3R enclosure.

1.1.14 Electrical Tests

The following electrical shop tests shall be performed, recorded and possibly witnessed at the manufacturers facility:

- AC Volt Input
- AC Amperes Input
- Apparent Watts Input
- True Watts Input
- AC Power Factor
- DC Volts Output
- DC Amperes
- DC Watts Output
- AC to DC Conversion Efficiency

- Dielectric Strength
- Transformer Primary to Ground
- Transformer Secondary to Ground
- Transformer Primary to Secondary
- Stack AC to Ground
- Stack DC to Ground
- Ripple Voltage at Full Output

1.1.15 Spare Parts

The transformer rectifier unit shall be supplying with all necessary start up spare parts as recommended by the manufacturer ie. fuses and indicating lamps ect.

1.1.16 Name Plate and Documentation

Each rectifier shall be provided with a stamped or engraved nameplate with following information:

- Name of manufacturer
- AC input volts
- AC input frequency
- No. of phases
- DC output volts
- DC output amperes
- Ambient temperature in degrees C
- Rectifier serial and model numbers

In addition, an operating and maintenance manual and a copy of the shop test data obtained on the final bench check of the rectifier shall be provided with the rectifier unit.

1.2 Mixed Metal Oxide Anodes

Mixed Metal Oxide anodes shall be supplied in accordance with the following specification:

Substrate Material	: Grade 1 Titanium to ASTM B-338
Coating	: Electrocatalytic - mixed metal oxide
Construction	: Tubular
Cable Connection	: Internal Center connected
Nominal Dimensions	: 1.25" diameter x 48" long
Design Life	: 25 years
Min. Output Capacity	: 7.62 amperes over 25 year design life
Cable Type	: HALAR insulation w/ HMWPE jacket

1.2.1 Cable Connection

The anode lead cable shall be attached internally in the longitudinal center of the tubular anode by means of a two-piece connector consisting of a matching pair of wedge shaped brass inserts.

The maximum resistance of the finished connection shall not exceed 0.004 ohms. The finished connection shall be sealed with a high density, slow-cure two-part epoxy resin and an asphalt base medium hard mastic sealer.

The anode lead wires shall be No. 8 AWG HALAR insulation with an HMWPE outer jacket. The conductor shall be stranded tinned copper. The length of the anode lead cable shall be 225 feet.

1.3 Coke Breeze Backfill Material

The coke breeze backfill shall be calcined petroleum grade and shall be dust free, blended, sized and shall conform to the following chemical and physical analysis:

Chemical Analysis	**Content %**
Fixed carbon	99.77 (min)
Volatile matter	0.0
Ash	0.1
Moisture	0.0

silver –silver chloride electrodes will be installed as an alternate to copper sulphate due to the high chloride ion content along the ROW which would otherwise contaminate a copper sulphate reference electrode.

Physical Analysis	
Bulk density	74 lbs. per cu ft
Max. particle size	0.04-inches

1.3.1 Environmental Earth Seal

An environmental earth seal plug shall be installed to a length of 5 feet above the top of the cokebreeze column. The material is manufactured by Loresco International under the product name Permaplug, although an equivalent product can be used.

1.3.2 Vent Pipe

One inch (1") diameter PVC perforated vent pipe as manufactured by Loresco International or equivalent shall be provided within the anode borehole from the bottom of the borehole extending approximately 8" above grade level within the 6" PVC surface casing.

The vent pipe shall have a wall thickness of 0.32" and have perforations or drilled holes on 360 degrees throughout the entire length of the borehole to vent gases to the atmosphere.

1.4 Main DC Cabling, Bonding Cables and Test Lead Wires

The cathodic protection DC cabling, positive, negative and test cables will be single conductor stranded copper with High Molecular Weight Polyethylene (HMWPE) insulation suitable for direct burial. The polyethylene coating shall conform to ASTM Standard D-1248.

1.5 Anode Junction Box

The anode lead junction box will supplied in a NEMA 4X corrosion resistant material such as fiberglass reinforced plastic FRP, or 316L stainless steel, and will include an insulating panel constructed of a bakelite material or G-10 fiberglass.

The junction box shall have nominal dimensions of 16" H x 12" W x 6" D and be designed for 4 or 6 circuits to terminate the individual anode lead cables of the anode groundbed.

Each circuit will be connected on a common copper bus and with No. 8 AWG terminal lugs and a 0.01 ohm, 8 Amp current measuring to allow the current output of each anode to be monitored. The main incoming terminal shall be supplied with a no. 4 to no. 2 AWG terminal lug.

The door of the anode junction box will be constructed with a stainless steel hinge and shall have lockable hasp and sealed using neoprene or polyurethane foam gaskets.

Two (2) 2-inch diameter aluminum NPT threaded conduit entry hubs will be provided for bottom cable entry into the junction box. The center-to-center spacing of the conduit hubs is 5 inches.

The junction box will be provided with a field fabricated steel support structure in accordance with the project drawings and a 18"W x 18"D x 24"H ready mix concrete foundation.

A 2" H x 6" L nameplate will be provided to the outer face of the door. The nameplate shall be adhered to the junction box enclosure with a two part epoxy compound. Self stick adhesive is not acceptable. The owner will provide the contractor with nomenclature and junction box identification information to be provided on each nameplate.

Refer to drawing no. D1-32461-C sheet 4, detail 6 for details of the anode junction box.

1.6 Negative Junction Box

The negative junction box will supplied in a NEMA 4X corrosion resistant material such as fiberglass reinforced plastic FRP, or 316L stainless steel, and will include an insulating panel constructed of a bakelite material or G-10 fiberglass.

The junction box shall have nominal dimensions of 16" H x 12" W x 6" D and be designed for a maximum of 6 negative cable terminations.

Each cable will terminate on a common copper bus bar with approximate dimensions of 8" L x 1" W x 0.25 D (thickness) supplied with 6 nos. x 0.5" diameter holes for termination of No. 4 or No. 2 AWG terminal lugs. The main incoming cable shall be supplied with a No. 4 AWG to No. 2 AWG terminal lug.

3/8" stainless steel hardware (nuts, bolts and washers) shall be used to terminate the cable lugs onto the copper bus.

The door of the negative junction box will be constructed with a stainless steel hinge and shall have lockable hasp and sealed using neoprene or polyurethane foam gaskets.

Two (2) 2-inch diameter aluminum NPT threaded conduit entry hubs will be provided for bottom cable entry into the junction box. The center-to-center spacing of the conduit hubs is 5 inches.

The junction box will be provided with a field fabricated steel support structure in accordance with the project drawings and a 18"W x 18"D x 24"H ready mix concrete foundation.

A 2" H x 6" L nameplate will be provided to the outer face of the door. The nameplate shall be adhered to the junction box enclosure with a two part epoxy compound. Self stick adhesive is not acceptable. The owner will provide the contractor with nomenclature and junction box identification information to be provided on each nameplate.

The negative junction box will incorporate a terminal block for termination of individual test wires.

Refer to drawing no. D1-32461-C sheet 4, detail 7 for details of the negative junction box.

Refer to drawing no. D1-32461-C sheet 3 for electrical schematics of the various cable terminations used for the standard sized negative junction box.

1.7 Test Stations

Flush to grade test stations with a removable terminal board as manufactured by Cott Manufacturing Co. (Flush Fink) or equivalent shall be used for termination of the reference electrode lead wire for monitoring the cathodic protection system. The test station cover shall indicate cathodic protection test station will be installed at the approximate locations as shown on the project drawings.

Test access holes shall also be flush to grade type as manufactured by Cott Manufacturing Co. or equivalent. This type of test access hole does not incorporate a removable terminal board.

Refer to drawing no. D1-32461-C, sheet 4 details 1 and 2 for information.

1.8 Permanent Reference Electrode

Permanent silver –silver chloride electrodes (Ag/AgCl) as manufactured by Corrpro Companies Inc., Borin Manufacturing Inc. or equivalent will be installed due to the high chloride ion content along the ROW which would otherwise contaminate a permanent copper sulphate reference electrode.

The reference electrode will have a design life in excess of 30 years.

The electrodes are comprised of a pure silver element, which is surrounded with a saturated solution of silver chloride gel. The element and solution are assembled within an approximate 2" diameter PVC tube with a special porous type plug in one end to allow contact with the electrolyte.

The maximum outer diameter of the packaged reference electrode shall be 3" to allow installation into a 4" augured hole.

The reference electrodes will have a stability of ±5% millivolt under 8.0 micro-amp load. Each electrode will be supplied with a 35 ft length of No. 12 or No. 14 AWG) single core stranded copper cable with RHW-USE insulation blue in color.

Refer to drawing D1-32461-C, sheet 4, detail 10 for typical installation details.

1.9 Negative Cable-to-Pipeline Connection

Stainless steel hardware shall be used for negative drain cable and negative test cable connections to the fabricated steel brackets that are to be welded to the bottom hinge of the manhole cover within the manhole vaults.

An epoxy compound or coal tar bitumastic compound will be applied to the bracket and bolted connection upon completion of the cable termination.

Refer to drawing no. D1-32641-C, sheet 4, detail 8 for typical installation details

1.10 Negative Cable-to-Electrical Ground Cable Connection

The exothermic weld process method (Thermoweld, Continental Industries, Inc.) or equivalent shall be used for the negative drain cable to copper ground connection.

Preferably, Type CC-2 (Tee) shall be used to make the no. 4 AWG negative cable to no. 2/0 AWG copper ground connection at CP system number 1 and 2.

Mold number M8260 and cartridge size 45 is used for the connection of a no. 4 AWG tap to a 2/0 AWG copper run. Consult the manufacturer for the correct model size for connection to a 4/0 AWG cable run if required.

1.11 PVC and RGS Conduit

1.11.1 PVC Conduit and Fasteners

1.5 –inch schedule 80 PVC conduit and PVC conduit straps are used to route the DC cables from the 'L' brackets to the topside of the deck floor at the chemical treatment structure located at the east side of the pump house for CP system no. 8.

The PVC conduit will be secured to the concrete wall above the 144" diameter pipeline using PVC conduit straps attached to the wall on 3 foot intervals with 5/16" stainless steel screws and plastic wall anchor plugs.

The DC cables will connect to the steel 'L' bracket welded to the top of the 144" CW return pipelines using stainless steel fasteners bolted to the bracket. The bracket and bolted connection will be painted with an epoxy coating or a coal tar bitumastic compound after the cable connections are tested for tightness.

1.5-inch schedule 80 PVC conduit will used to interconnect between the two negative junction boxes associated with CP system no. 8. The PVC conduit will be mounted to the vertical wall of the chemical treatment structure just above the top of the 144" HRC pipelines using PVC conduit straps attached to the wall on 3 foot intervals with 5/16" stainless steel screws and plastic wall anchor plugs.

Note: Only the PVC conduit and DC cabling associated with Unit 2 – 144" HRC pipelines can be installed during the scheduled plant shutdown in April 2006.

The PVC conduit and DC cable installation for Unit 1 144" HRC pipelines can only be conducted during the scheduled shutdown of Unit 1 in April of 2007.

Refer to drawing no. D1-32641-C, sheet 4, detail

1.11.2 RGS Conduit and Fasteners

1.5 –inch rigid galvanized steel conduit and galvanized conduit straps are used to route the DC cables from the 'L' brackets inside the instrument vaults and manhole vaults to grade level.

The conduit shall be secured to the inside wall of the instrument/manhole vaults using galvanized conduit straps and with 5/16" stainless steel screws and plastic wall anchor plugs.

Refer to drawing no. D1-32641-C, sheet 4, detail 8 for installation details.

APPENDIX D

BILL OF MATERIALS

		no. 12 AWG cables. 2 x 2" NPT threaded hubs in the bottom of box. 16" H x 12" W x 6" D nominal dimensions. Supplied with 6 sets Stainless steel bolts/nuts and lock washers for cable lug termination to bus. Per project specifications and detail 7 of the project drawings		
9	35 no.	Test Station: Cott Flush Fink Type or equiv., 3 brass terminals, locking cover, with 3" x 5' long plastic conduit		
10	4 no.	Test Station Access Hole: Cott Flush Fink Type or equiv., locking cover supplied without terminal board .		
11	4 no.	Test Station Access Hole: Flush to grade Traffic type, Handley or equiv, locking cover supplied without terminal board.		
12	5250 ft	Cable: No. 2 AWG, 1-conductor stranded copper with HMWPE insulation for main positive and negative header cables.		
13	9800 ft	Cable: No. 4 AWG, 1-conductor stranded copper with HMWPE for positive / negative header cables		
14	700 ft	Cable: No. 12 AWG, 1-conductor stranded copper with HMWPE black insulation for test wires.		
15	5 rl	Electrical Cable warning tape – 6" wide (1000 ft / roll)		
16	1 no.	Thermoweld Mold with handle for no. 4 AWG negative cable to no. 2/0 AWG ground cable run: Model no. M8260		
17	1 bx	Thermoweld cartridge: Size #45 for copper to copper connection. (20 / box)		
18	35 no.	Reference Electrode: Silver/Silver Chloride, 30 year design life, 3" dia. max prepackaged size, supplied with 35 feet No. 12 AWG RHW-USE cable – Blue, as manufactured by Borin Manufacturing or Corrpro Companies		
19	156 bag	Cokebreeze: Loresco SC-2 or 3 or equivalent, (qty calculated at 100 lbs per bag)		
20	183 pc	Vent Pipe: Perforated schedule 80 PVC vent pipe, 20 ft per piece – Loresco or equiv. supplied with 1" PVC coupling (qty calculated at 20 ft per piece)		

21	88 no.	Anode centralizer for 6" diameter hole – Eltech or equivalent		
22	28 bag	PermaPlug casing sealant: Loresco or equiv. (qty calculated at 50lb per bag)		
23	400 ft	6" dia. PVC surface casing		
24	20 no.	6" PVC end cap		
25	40 no.	1" 90 deg elbow		
26	20 ft	1" PVC conduit		
27	2 cn	PVC Cement – 1 quart / can		
28	10 rl	Vinyl tape: ¾" wide		
29	As required	PVC Permanent Cable Identification System, Numbers 0-9, Letters A-Z, PVC plastic identification system fixed to cable with wire ties		
II. Construction Materials				
30	300 ft	Conduit: 1.5" RGS electrical conduit		
31	50 ft	Conduit: 1.5" sch 80 PVC electrical conduit		
32	375 ft	Conduit: 2" RGS electrical conduit for Junction Box cables		
33	10 lb	Conduit sealing compound		
34	150 pc	Conduit Strap: PVC Wall mount		
35	150 pc	PVC wall anchor plug: 5/16"		
36	150 pc	5/16" x 1.5" L SS screw for wall anchors		
37	1 gal	2 part, fast set corrosion protection epoxy		
38	150 sets	SS fasteners, 1/4" 1 set = 3/8" x 1.5" bolt, nut, flat and lock washer for junction box mounting		
39	64 set	SS fasteners, 3/8" 1 set = 3/8" x 1.5" bolt, nut, flat and lock washer for negative cable to bracket connection		
40	12 no.	Steel bracket- 1" W x 6" L x ¼" T with 3 drilled 0.5" diameter holes, per detail 8		
41	4 no.	Steel 'L' bracket – 2" x ¼" plate. 4 inches H x 4" L (L-shape) bracket w, 3 x 0.5" drilled hole, per detail 9		
42	16 no.	Junction box support frame: Anode / Negative fabricated from 4" C-Channel – painted, with 12" x 12" x 24" concrete foundation, per detail 6 and 7.		
43	8 no.	Rectifier mounting frame: Fabricated from 4" C channel, Galvanized, with 60 L" x 30" W x 18" H concrete foundation. per detail 11		
44	As Req'd	Sand – Trench backfill		

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HARVEY TRUCKING

P.O. Box 6866
1408 Perrineville Road
Monroe Twp., NJ 08831
(609) 371-7600
Fax: (609) 371-7630

Shipper's No. 4911

Carrier

Carrier's No. 9446

RECEIVED, subject to the classifications and tariffs in effect on the date of the issue of this Bill of Lading,

at GARWOOD, NJ 3/28 20 08 from CASALE INDUSTRIES

Consigned to INTERMOUNTAIN POWER SERVICE CORP.

(Mail or street address of consignee—For purposes of notification only.)

Destination DELTA State UT. Zip Code 84624 County

Delivery Address ★ 850 WESTRX BRUSH WELLMAN RD. CONTACT GARY CHRISTENSEN

(★To be filled in only when shipper desires and governing tariffs provide for delivery thereat.) 435-864-6486

Route

Delivering Carrier Car or Vehicle Initials No.

No. Packages	Kind of Package, Description of Articles, Special Marks, and Exceptions	*Weight (Sub. to Cor.)	Class or Rate	Check Column
8	FULEL INJECTORS	20,000		
1	FIBERGLASS WARP TAPE			
	ABT PO A07-008-414			

Subject to Section 7 of Conditions of applicable bill of lading, if this shipment is to be delivered to the consignee without recourse on the consignor, the consignor shall sign the following statement:
The carrier shall not make delivery of this shipment without payment of freight and all other lawful charges.

(Signature of Consignor.)

If charges are to be prepaid, write or stamp here, "To Be Prepaid."

Received $ to apply in prepayment of the charges on the property described hereon.

Agent or Cashier

Per
(The signature here acknowledges only the amount prepaid.)

Charges Advanced:
$

*If the shipment moves between two ports by a carrier by water, the law requires that the bill of lading shall state whether it is "carrier's or shipper's weight."
NOTE—Where the rate is dependent on value, shippers are required to state specifically in writing the agreed or declared value of the property.
The agreed or declared value of the property is hereby specifically stated by the shipper to be not exceeding

per

†"The fibre boxes used for this shipment conform to the specifications set forth in the box maker's certificate thereon, and all other requirements of Uniform Freight Classification."
‡Shipper's imprint in lieu of stamp; not a part of bill of lading approved by the Interstate Commerce Commission.

Shipper, Per Agent, Per

Permanent post-office address of shipper

4-2-08

IP12_003741

STRAIGHT BILL OF LADING–SHORT FORM-ORIGINAL-NOT NEGOTIABLE — DESIGNATE WITH AN (X) BY TRUCK ☒ FREIGHT ☐

RECEIVED, subject to the classifications and lawfully filed tariffs in effect on the date of issue of this Original Bill of Lading, the property described below, in apparent good order, except as noted (contents and condition of contents of packages unknown), marked, consigned and destined as indicated below, which said carrier (the word carrier being understood throughout this contract as meaning any person or corporation in possession of the property under the contract) agrees to carry to its usual place of delivery at said destination, if on its route, otherwise to deliver to another carrier on the route to said destination. It is mutually agreed, as to each carrier of all or any of said property over all or any portion of said route to destination, and as to each party at any time interested in all or any of said property, that every service to be performed hereunder shall be subject to all the terms and conditions of the Uniform Domestic Straight Bill of Lading set forth (1) in Uniform Freight Classification in effect on the date hereof, if this is a rail or a rail-water shipment, or (2) in the applicable motor carrier classification or tariff if this is a motor carrier shipment.

Shipper hereby certifies that he is familiar with all the terms and conditions of the said bill of lading, including those on the back thereof, set forth in the classification or tariff which governs the transportation of this shipment, and the said terms and conditions are hereby agreed to by the shipper and accepted for himself and his assigns.

From: Casale Industries Inc.
At: 400 South Ave.
Garwood, N.J. 07027

DATE: 3-28-08

SHIPPER'S NO.: 4911

CARRIER'S NO:

CARRIER BY: Harvey Trucking

CONSIGNEE AND DESTINATION:
Intermountain Power Service Corp.
850 West Brush Wellman Road
Delta, Utah. 84624-9546

ROUTE:

DELIVERING CARRIER:

CAR OR VEHICLE INITIALS & NO.:

NO. PACKAGES	HM	DESCRIPTION OF ARTICLES, SPECIAL MARKS AND EXCEPTIONS	*WEIGHT	CLASS OR RATE	✓
8		Fuel Injectors (4) ccw (4) cw	2,500/each		
1		FIBERGLASS DROP WARP TAPE 1300'			
		ABT PO# A07-008-414			
		Deliveries made Mon-Fri			
		0700 thru 1600 local time			
		Contact: Garry Christensen			
		(435-864-6486)			
		* 3rd Party Billing - ABT-271 Route 202/206 *			
		P.O. Box 410			
		Pluckemin, NJ 07978			

Subject to Section 7 of conditions of bill of lading, if this shipment is to be delivered to the consignee without recourse on the consignor, the consignor shall sign the following statement.
The carrier shall not make delivery of this shipment without payment of freight and other lawful charges.

Per ______ (Signature of Consignor)

If charges are to be prepaid, write or stamp here, "To be Prepaid."

Received $ ______ to apply in prepayment of the charges on the property described hereon.

______ Agent or Cashier.

Per ______
(The signature here acknowledges only the amounts prepaid.)

Charges Advanced:

When transporting hazardous materials include the technical or chemical name for n.o.s. (not otherwise specified) or generic description of material with appropriate UN or NA number as defined in US DOT Emergency Response Communication Standard (HM-126C). Provide emergency response phone number in case of incident or accident. (In box at right)

EMERGENCY RESPONSE PHONE NO

SHIPPERS CERTIFICATION: This is to certify that the above-named materials are properly classified, described, packaged, marked and labeled, and are in the proper condition for transportation according to the applicable regulations of the Department of Transportation. SIGNATURE ______ TITLE ______

*If the shipment moves between two ports by a carrier by water, the law requires that the bill of lading shall state whether it is "carrier's or shipper's weight"
† Shipper's imprints in lieu of a stamp; not a part of the Bill of Lading approved by the Interstate Commerce Commission.
Note - Where the rate is dependent on value, shippers are required to state specifically in writing the agreed or declared value of the property.
The agreed or declared value of the property is hereby specifically stated by the shipper to be not exceeding ______

THIS SHIPMENT IS CORRECTLY DESCRIBED.
CORRECT WEIGHT IS ______ LBS

†The fibre boxes used for this shipment conform to the specifications set forth in the box makers certificate thereon, and all other requirements of the Consolidated Freight Classification.

Per ______

Shipper, Per Jim Burger A.

0865658

TEMP-PRO INC.
200 INDUSTRIAL DRIVE
P.O. BOX 89
NORTHAMPTON, MA 01061-0089
PHONE (413) 584-3165
FAX (413) 586-3625

Packing List

SALESPERSON: NM
DATE: 03/10/08

TO:
ADVANCED BURNER
271 ROUTE 202/206
PO BOX 410

PLUCKEMIN, NJ 07978

08-64792

SHIP TO:
INTERMOUNTAIN POWER SERVICE CORP
850 WEST BRUSH WELLMAN RD
DELTA, UTAH 84624 Zip Code

ACCOUNT	PLACED	ACTUAL SHIP DATE	CUST ORDER #	YOUR P.O. NUMBER
1749	12/31/07	Back Order	071212J14	A07-008-416

QTY DUE	PART #/DESCRIPTION	[redacted]	Qty. Shipped	[redacted]	Qty. B.O.	[redacted]
47	ST-8866B-1 FUEL INJECTOR NOZZLE T/C SHIP VIA BEST WAY FREIGHT PREPAID		47		0	
47	ST-8866B-2 FUEL BODY TEMP T/C SHIP VIA BEST WAY FREIGHT PREPAID		47		0	

1 CRATE

Number of Cartons: ______ Total Weight: 230

WHITE - Customer WHITE - Office YELLOW - Job Packet WHITE - Packing List

IP12_003743

CONSIGNEE DELIVERY RECEIPT

Freight Bill Number: 1496428264 R0 **TNBR Number:** **DATE:** 03/25/2008

Consignee	Shipper
INTERMOUNTAIN POWER SER 850 W BRUSH WELLMAN RD DELTA UT 84624-9522 US Trailer # 2311710	TEMP PRO INC 200 INDUSTRIAL DR NORTHAMPTON MA 01060 US

PIECES	H/U	HM	DESCRIPTION	WGT(LBS)	NMFC	PCF	CLASS	RATE	TOTAL CHARGES
1			435-864-6486 :CONS PHONE # 1-413-584-3165 :SHIP PHONE # GARRY CHRISTENSEN APPOINTMENT DELIVERY ** SENSORS 1 SKIDS SCHED032708 00:00 SETUP032708 16:07 LEFT MESSAGE US (435)864-6486 BEFORE: BUWI03/26/2008 FXF INTERREG FUEL SURCHG LTL SHPT19.90% APPOINTMENT FROM 07:00 TO 17:00 APPT 040108 17:00SETUP032808 09:13 GARRY US (435)864-6486	230	133390-03		085		
1	1		PREPAID - WILL INVOICE	230					

RECEIVED APR 01 2008 BY B/O GROUP

ANY ADDITIONAL SERVICES MAY RESULT IN ADDITIONAL CHARGES
CHARGES SUBJECT TO CHANGE

Bill of Lading Number 0.00

Delv. Driver & #:

P.O. Number

Page 1 of 1

Date:	Arrive:	Depart:
# of Skids:	# of Pcs:	OS&D #:

Shipment received in apparent good order with wrap intact unless otherwise noted.

Received by: ______________________

☐ Over ☐ Damage Exceptions:
☐ Short ☐ Wrap Broken

FedEx Freight

LONG-HAUL RELIABILITY

P.O. BOX 649002
SAN JOSE, CA 95164
fedex.com 1.866.393.4585

IP12_003744

APPENDIX E

CONSTRUCTION SCOPE OF WORK

APPENDIX E

CATHODIC PROTECTION OF PCC CIRCULATING WATER PIPELINES

CONSTRUCTION SCOPE OF WORK

1.0 GENERAL INSTALLATION PROCEDURES

The construction work for this project includes the complete installation of eight (8) impressed current cathodic protection systems using deep anode groundbed configurations.

Refer to Cathodic Protection System drawing number D1-32461-C, sheets 1 to 5. For CP equipment location, refer to sheet no. 1 and 2, for the schematic diagrams of each system, refer to sheet 3, and for installation details and notes, refer to sheet no. 4 and 5.

Refer to IPSC underground utility drawing numbers, 9255-9STU-S3311, 9255-9STU-S3312 and 9255-9STU-S3338, for the underground structures to be avoided when conducting the construction work activities.

The following sections outline the general installation guidelines for this cathodic protection arrangement.

1.1 DEEP ANODE GROUNDBED INSTALLATION

1.1.1 Final Positioning of the CP Anode Groundbeds

The Contractor is required to obtain and submit all applications/permits for well drilling required by IPSC. The contractor shall employ the services of a GPS surveyor approved by the owner to locate and mark the C/L position and edges of the circulating water pipelines at each of the proposed deep anode groundbed locations as shown on the drawings. There are 20 deep anode groundbed installations.

The surveyor will also locate and mark each of the 20 deep anode groundbed locations. The anode groundbed should be located 10 to 15 feet adjacent to the edge of the PCC pipeline wall. The groundbed can be located up to 50 feet in either direction laterally to suite site conditions. If this is not sufficient to clear any onsite obstacles, contact the owner / design engineer for further advise.

Although not mandatory, it may prove useful to utilize MCM Engineering to conduct the GPS surveying requirements of the project. This company has conducted numerous GPS surveys for the owner and has a large database of information pertaining to this site.

Verification of actual field conditions, location of underground structures, and physical non-interference with other structures or utilities shall be the responsibility of the Contractor. Consult the underground utility drawings as identified on the cathodic protection drawings while conducting the GPS survey with the surveying company.

1.1.2 Drilling of Boreholes

Refer to drawing no. D1-32641, sheet 4, detail 5.

The augured anode hole shall be 6-inch diameter by 170 or 190 feet deep for a 4 anode and 6 anode installation respectively. Drilling of the holes will require the installation of 6-inch x 20 ft PVC surface casing. The surface casing shall extend12 inches above grade level.

Drilling shall be accomplished with rotary bit equipment designed specifically for this purpose. Driller shall use standard techniques (i.e. trough and vacuum truck) to capture and contain the drilling fluids, mud and cuttings at the top of the hole. The driller shall select the type and consistency of drilling fluids or drilling mud to be consistent with the soil characteristics of the site. The drilling rig shall be leveled as accurately as possible to provide a round, straight and plumb anode hole.

The contractor shall take precautions to avoid entrance of foreign matter into the hole.

Drilling mud, cuttings and other waste shall be disposed of on-site by the drilling contractor in accordance with IPSC regulations.

The final depth of the borehole shall be measured by the drilling contactor and recorded.

1.1.3 Anode Installation

Refer to drawing no. D1-32461, sheet 4, detail 5 for installation details.

Four (4) or (6) anodes will be installed in the drilled borehole. The 1.25" x 48" long mixed metal oxide anodes are spaced at 6 foot end-to-end intervals.

Each anode will be fitted with an anode centralizer One per anode, which is clamped onto the MMO anode at the center of the anode. The clamp is securely tightened around the anode tube using a screwdriver.

The bottom end of the first anode installed in the hole shall be positioned 5 feet above the bottom of the hole.

It is good practice to layout the anode cables adjacent to the anode borehole prior to installation. Measure and mark each anode cable at the precise depth that the anode is to be lowered to, measuring from the bottom of the anode up toward the end of the cable.

Assuming a final drilled bore hole depth of 170 feet, the first anode would be marked with tape on the anode lead cable at a total distance of 161 feet from the bottom of the anode. This represents 5 feet from the bottom of the hole for cokebreeze backfill installation and the 4 foot anode length = 9 ft. 170 – 9 ft = 161 feet. The second anode would be measured and marked 155 ft from the bottom of the anode which represents a 6 foot end-to-end spacing.

The anodes and vent pipe are lowered into the hole together until the cable markings on the anodes are flush to grade surface.

The vent pipe described in section 1.1.5 is installed at the same time as the anodes. The first anode is secured to the vent pipe (which is capped on the end) with tape or secured using the anode centralizer to the vent pipe and anode, at a distance of 5 feet from the bottom end of the anode and the bottom end of the vent pipe.

Each subsequent anode is secured to the vent pipe on 6 foot end-to-end anode spacings. The anode cables are secured to the vent pipe on approximate 6 foot intervals using three wraps of vinyl tape. **Note:** The anode centralizer may have a clamp which is also used to secure the anode to the vent pipe.

The anodes shall be lowered into the 6-inch diameter hole until the designated depth of the anode is achieved (i.e , 170 or 190 feet below grade). The anode cables shall then be temporarily tied-off to an above grade structure to ensure the proper anode depth is maintained during the backfilling process.

The anodes will be numbered with the first anode in the hole (ie. the bottom anode) identified as anode number one (1). Care shall be taken in lowering anodes to avoid hang-ups in the well. Extreme care shall be exercised against damaging the anode lead wires during this operation.

Under no circumstances shall the anode lead wires be clamped or pinched around another object while lowering the anode assembly into the hole. If the insulation of any anode lead wires are cut, broken, or nicked during this operation or at any other time, the complete anode shall be rejected from use and shall be removed from the job site immediately.

After the backfilling of the anodes is complete, the anode cables shall be permanently tied off in a loop fashion around a 1-inch diameter x 8 inch length of PVC conduit that is positioned inside and through the center of the surface casing at a depth of 6 to 10 inches from the top of the surface casing.

The anode cables shall then be routed to and exit through a 2-inch hole drilled through the side of the 6-inch surface casing. The anode cables will then run to the anode junction box located directly adjacent to the deep anode groundbed borehole.

1.1.4 Vent Pipe Installation

One inch(1") diameter perforated vent pipe shall be used from the bottom to the top of the hole. Typically, two joints are assembled above ground at a time, and secured to the anode cables with tape on approximate 6 foot intervals. The vent pipe and anode(s) are then lowered into the hole together, maintaining a 6 foot end-to-end anode spacing.

PVC cement will be used to join sections of vent pipe. The bottom of the vent pipe shall be capped. The top of the vent pipe shall be temporarily capped throughout the coke breeze backfill process to prevent intrusion of foreign material. Care shall be exercised to avoid intrusion of drilling mud into the vent pipe.

The vent pipe is lowered into the hole at the same time the anodes are lowered into the hole. Refer again to section 1.1.3 above.

The 1" vent pipe shall terminate 4 inches above grade within the 6-inch PVC surface casing. The top end of the vent pipe shall be fitted with two 90 degree elbows to form a 180 degree 'U' which allows gas from the anode hole to be released.

1.1.5 Coke Breeze Backfill Installation

The coke backfill shall be slurried above-grade in a 500 gallon container with fresh water and then pumped into the borehole from the bottom up to 5 feet above the top of the top anode in the hole. The coke backfill shall be pumped from the bottom of the hole up using a pipe that is the length of the anode hole. The pipe used to pump the coke into the hole shall not be the vent pipe. The pipe shall be raised as the anode column is filled with coke. The pipe shall be removed from the hole after the coke installation operation is completed. A sufficient amount of backfill shall be used such that the coke breeze column will extend a minimum of 5 feet above the top of the uppermost anode. Extreme care shall be exercised during installation of the coke backfill so that no voids remain around the anodes. This is best assured by slowly pumping the cokebreeze into the casing.

The slurry mixture shall be approximately 100 lbs of cokebreeze per 7 gallons of fresh water.

By calculation, 750 lbs of cokebreeze inclusive of a 10% contingency are required for a 4 anode installation (170 ft hole). 1060 lbs of cokebreeze inclusive of a 10% contingency are required for a 6 anode installation (190 ft hole).

The cokebreeze backfill is poured into a tank of sufficient size along with the required amount of water. At the same time, the pump is used to stir the mixture by means of a by-pass valve A, valve B (to the anode hole) being closed. After the mixture is fluidized, valve B is opened (leaving valve A open to keep the mixture fluidized) and the mixture is pumped from the bottom of the hole up until all cokebreeze backfill is gone from the mixing container. One pumping begins, it should not be interrupted until all cokebreeze is in place. This will result in the cokebreeze backfill being approximately 5 feet above the top anode in the hole.

After the cokebreeze has settled for 24 hours, a second measurement should be conducted by lowering a plumb on a string to ensure that the cokebreeze column is indeed 5 feet from the top of the top anode. This measurement should be 136 feet from grade level to the top of the cokebreeze column for a 4 anode installation, and 126 feet from grade level for a 6 anode installation. If the distance to the top of the cokebreeze column is less than this, (considering the actual start depth of the borehole), then additional cokebreeze backfill should be mixed into a pour able slurry and poured into the hole from the top of the anode groundbed.

1.1.5.1 Environmental Seal

An environmental earth seal plug shall be installed to a length of 5 feet above the top of the cokebreeze column. The material is manufactured by Loresco International under the product name Permaplug, although an equivalent product can be used.

After the carbon backfilled has settled and is at the correct height in the hole, flush the hole with clean water, then pour the correct amount of PermaPlug into the top of the borehole. A 6" dia. hole will require 13.7 lbs of PermaPlug per linear foot, therefore approximately 70 lbs of sealant will be used to seal 5 feet above the anode borehole.

Eight (8) hours after the sealant has been poured into the hole, the hole shall be filled with native soil to a depth of 2 feet below grade level within the 6 inch surface casing

The anode borehole is then completed by installing a 6-inch diameter PVC end cap cover over the top of the 6" surface casing cut off at a level of 6-inches above grade.

The 6" end cap shall be provided with Two (2) 0.5-inch diameter drilled holes to vent chlorine gas to the atmosphere.

1.1.6 Concrete Foundation

An 18" x 18" x 8" ready mix concrete foundation shall be formed around the 6-inch surface casing extending 2" above grade level.
Alternatively, in concrete or paved paved areas, a suitable knock out of approximately 18" x18" in dimension shall be cut out directly above the anode well and filled in to grade level with ready mix concrete to form the foundation

1.2 Transformer Rectifiers

Refer to drawing no. D1-32461, sheet 5, detail 11.

The main contractor shall subcontract the AC power supply work to an owner approved electrical contractor to provide the design, materials and labor required to provide AC power from the owner designated MCC to the transformer rectifier units.

Eight (8) transformer rectifiers will be located per the approved locations as determined by the owner and may be located outside or inside. The proposed locations of the units are shown on drawing no, D1-32641-C, sheets 1 and 2.

For outdoor installations, the rectifiers will be mounted on a 4-inch C-channel frame secured to a concrete foundation pad.

For indoor installations, the rectifier units may be wall mounted.

The rectifier units will require 115 volt/ single phase/ 60 Hz AC input power supply.

Refer to section 3.6.5 of the cathodic protection design document for the AC amperage requirements for each of the eight transformer rectifier units.

1.3 Test Stations

Refer to drawing no. D1-32461-C, sheet 4 details 1 and 2 for installation details

Test stations will be installed at the locations shown on the design drawings.

Flush to grade test stations with a removable terminal board are used for termination of the reference electrode lead wire for monitoring the cathodic protection system.

Test access holes shall also be a flush to grade type. This type of test access hole does not incorporate a removable terminal board.

1.4 DC Cabling

Refer to drawing no. D1-32461-C, sheet 4 details 3 and 4 for installation details.

The cathodic protection drawing identifies the location of each of the cable termination points, the cable size and approximate location of junction box and rectifier units associated with each system. The contractor is responsible for determining the final cable routing between the equipment. If additional cable is required to complete the installation, the applicable unit rate schedule as outlined in the contract for material and labor will apply.

All cables supplied are suitable for direct burial and the DC cables will be installed in common trenches wherever possible.

The trenches required for the installation of the direct burial cables shall have a minimum depth of 18-inches. A cable warning tape shall be positioned directly over the cables at a depth of 12-inches below grade. Trenches shall be of sufficient width to ensure the proper installation of the cables. The banks of trenches shall be as nearly vertical as practicable. The bottom of the finished trench shall be free from sharp stones or other materials, which might damage the insulation of the cables. 1-inch of clean sand shall be installed below and above the direct buried cables

All backfill materials shall be clean selected excavated materials, free from stones larger than 50 mm in diameter. The backfill material shall be compacted and tamped to the approximate density of the adjacent soil. The excavated surface shall be restored to its original condition.

The cables shall be routed inside suitably sized rigid galvanized steel conduit under road and roil road crossings.

All cables shall be permanently labeled in accordance with owner requirements.

1.4.1 Cable Terminations

The negative and positive cables will terminate on a copper bus bar within the appropriate junction box. The negative cable connections made to the pipeline steel brackets shall use 3/8" or ¼" stainless steel bolts, nuts and washers.

The contractor shall supply and weld cable termination brackets to the pipeline or it's manhole cover.

Refer to drawing no. D1-32461-C, sheet 4 detail 8 and 9 for details of the mounting brackets required to be welded to the pipelines.

A corrosion protection epoxy shall be applied to the steel bracket and cover the bolted cable connection.

1.4.2 Cable Terminations at CP System 1 and 2

The negative drain cable connections required for CP system number 1 and 2 will be made to the plant electrical grounding system.

The exothermic weld process will be utilized to make this copper cable to copper cable 'T' type connection.

The no. 4 AWG negative run cable will connect to a no. 2/0 or 4/0 AWG copper grounding cable in the vicinity of the condenser building.

Thermoweld Type CC-2, no. 4 AWG tap to no. 2/0 WAG run cable-to-cable connection will use Mold number M-8260 and a size 45 cartridge.

Consult the manufacturer for the correct mold size require for 4/0 AWG cable run, or for information if different supplier than Thermoweld is used.

1.5 Reference Electrode Installation

Refer to drawing no. D1-32461-C, sheet 4 detail 10 for installation details.

Refer to section 1.1 above. The contractor shall employ the services of a GPS surveyor approved by the owner to locate and mark the C/L position and edges of the circulating water pipelines at each of the proposed reference electrode installation locations as shown on the drawings. There are 35 permanent reference electrode installations and 8 test access hole locations to be installed.

The reference electrodes shall be installed 2.5 to 3 feet from the edge of the PCC pipe and no greater than pipe depth. The no. 12 AWG wire shall terminate on the terminal board of the test station which is positioned directly over the centerline of the pipeline associated with the reference electrode.

The depth of the pipe ranges from 9.5 to 22 feet below grade elevation, and BOP elevations are included on the cathodic protection drawings. The GPS contractor shall provide grade elevations from which to determine the bottom depth of the pipelines. The IPSC utility drawings indicate the bottom elevation depth of the PCC pipelines.

The test access holes only need GPS positioning directly over the centerline of the PCC pipes.

Although not mandatory, it may prove useful to utilize MCM Engineering to conduct the GPS surveying requirements of the project. This company has conducted numerous GPS surveys for the owner and has a large database of information pertaining to this site.

Verification of actual field conditions, location of underground structures, and physical non-interference with other structures or utilities shall be the responsibility of the Contractor. Consult the underground utility drawings as identified on the cathodic protection drawings while conducting the GPS survey with the surveying company.

1.6 Anode and Negative Junction Box Installation

Refer to drawing no. D1-32461-C, sheet 4 detail 6 and 7 for typical installation details of the anode junction box and negative junction box respectively.

The anode junction box will be positioned 1 to 2 feet immediately adjacent to the deep anode groundbed.

The negative junction boxes will be located at a convenient location near the negative cable point of termination away from vehicle traffic.

The 2" RGS conduit shall be supplied with 2" end bushings to protect the cables during installation.

A sealing compound, plastic or expandable foam shall be used to seal the cables inside the terminal box within the 2" RGS conduit.

The junction box support frame and concrete foundations shall be field fabricated to meet the dimensions of the supplied junction box dimensions. Stainless steel fasteners shall be used to attach the junction box to the support frame.

Refer to the negative junction box schematic diagrams on sheet 3 of drawing no. D1-32641 for the required pipeline terminations for each of the negative junction boxes.

APPENDIX F

UNIT RATE SCHEDULE FOR BID

APPENDIX F

UNIT RATE SCHEDULE

CORROSION PROTECTION OF CIRCULATING WATER PRESTRESSED CONCRETE CYLINDER PIPELINES

1.0 Equipment Supply
Refer to Appendix C - Equipment Specification for the requirements of the cathodic protection equipment.

Item	Qty	Description	Unit Price US$	Total Price US$
I. Cathodic Protection Equipment				
1	3 no.	Transformer Rectifier: Two (2) Circuit - 30 volt / 30 amp DC output each Circuit, Constant Current, SCR silicon diode rectification, Potentiometer DC output controlled, 115 Volt/ 1 phase / 60 Hz input, AC/DC lightning protection, dry contact current interruption terminals on front panel (all 2 circuits same time), normal / fault indication lights, air cooled, NEMA 3R, non-explosion proof – Per project specifications		
2	2 no.	Transformer Rectifier: Three (3) Circuit - 30 volt / 30 amp DC output each Circuit, Constant Current, SCR silicon diode rectification, Potentiometer DC output controlled, 115 Volt/ 1 phase / 60 Hz input, AC/DC lightning protection, dry contact current interruption terminals on front panel (all 3 circuits same time), normal/fault indication lights, air cooled, NEMA 3R, non-explosion proof – Per project specifications		
3	1 no.	Transformer Rectifier: Four Circuit (4) Circuit - 30 volt / 30 amp DC output each Circuit, Constant Current, SCR silicon diode rectification, Potentiometer DC output controlled, 115 Volt/ 1 phase / 60 Hz input, AC/DC lightning protection, dry contact current interruption terminals on front panel (all 4 circuits same time), normal / fault indication lights, air cooled, NEMA 3R, non-explosion proof – Per project specifications		

4	2 no	Transformer Rectifier: Two (2) Circuit - 32 volt / 40 amp DC output each Circuit, Constant Current, SCR silicon diode rectification, Potentiometer DC output controlled, 115 Volt/ 1 phase / 60 Hz input, AC/DC lightning protection, dry contact current interruption terminals on front panel (all 2 circuits same time), normal / fault indication lights, air cooled, NEMA 3R, non-explosion proof – Per project specifications		
5 3a 3b 3c	88 total 30 no 30 no. 28 no.	Anode: Tubular titanium with mixed metal oxide coating, 1.25" dia. x 48" long, center connected, with the following lengths of No. 8 AWG stranded copper with HALAR insulation and HMWPE outer jacket lead wire, per project specifications: - 210 ft - 175 ft - 150 ft		
6.	16 no.	Positive Distribution Box: 4 circuits, FRP or SS construction, NEMA 4X, SS piano hinge and latches, G-10 fiberglass or bakelite panel board with common copper bus bar with 4 circuits, each circuit with a No. 8 AWG terminal lug and 0.01 ohm/ 8 amp shunt, with 2 x 2" NPT threaded hubs in the bottom of box. 18" H x 12" W x 6" D nominal dimensions. Per project specifications and detail 6 of the project drawings.		
7.	4 no.	Positive Distribution Box: 6 circuits, FRP or SS construction, NEMA 4X, SS piano hinge and latches, G-10 fiberglass or bakelite panel board with common copper bus bar with 6 circuits, each circuit with a No. 8 AWG terminal lug and 0.01 ohm/ 8 amp shunt, with 2 x 2" NPT threaded hubs in the bottom of box. 18" H x 12" W x 6" D nominal dimensions Per project specifications and detail 6 of the project drawings		
8	16 no.	Negative Junction Box: G-10 fiberglass or Bakelite panel board with Common copper bus bar w/ 6 x 0.5" drilled holes for cable termination. Terminal block for 4 individual no. 12 AWG cables. 2 x 2" NPT threaded hubs in the bottom of box. 16" H x 12" W x		

		6" D nominal dimensions. Supplied with 6 sets Stainless steel bolts/nuts and lock washers for cable lug termination to bus. Per project specifications and detail 7 of the project drawings		
9	35 no.	Test Station: Cott Flush Fink Type or equiv., 3 brass terminals, locking cover, with 3" x 5' long plastic conduit		
10	4 no.	Test Station Access Hole: Cott Flush Fink Type or equiv., locking cover supplied without terminal board .		
11	4 no.	Test Station Access Hole: Flush to grade Traffic type, Handley or equiv, locking cover supplied without terminal board.		
12	5250 ft	Cable: No. 2 AWG, 1-conductor stranded copper with HMWPE insulation for main positive and negative header cables.		
13	9800 ft	Cable: No. 4 AWG, 1-conductor stranded copper with HMWPE for positive / negative header cables		
14	700 ft	Cable: No. 12 AWG, 1-conductor stranded copper with HMWPE black insulation for test wires.		
15	5 rl	Electrical Cable warning tape – 6" wide (1000 ft / roll)		
16	1 no.	Thermoweld Mold with handle for no. 4 AWG negative cable to no. 2/0 AWG ground cable run: Model no. M8260		
17	1 bx	Thermoweld cartridge: Size #45 for copper to copper connection. (20 / box)		
18	35 no.	Reference Electrode: Silver/Silver Chloride, 30 year design life, 3" dia. max prepackaged size, supplied with 35 feet No. 12 AWG RHW-USE cable – Blue, as manufactured by Borin Manufacturing or Corrpro Companies		
19	156 bag	Cokebreeze: Loresco SC-2 or 3 or equivalent, (qty calculated at 100 lbs per bag)		
20	183 pc	Vent Pipe: Perforated schedule 80 PVC vent pipe, 20 ft per piece – Loresco or equiv. supplied with 1" PVC coupling (qty calculated at 20 ft per piece)		
21	88 no.	Anode centralizer for 6" diameter hole – Eltech or equivalent		
22	28 bag	PermaPlug casing sealant: Loresco or equiv.		

		(qty calculated at 50lb per bag)		
23	400 ft	6" dia. PVC surface casing		
24	20 no.	6" PVC end cap		
25	40 no.	1" 90 deg elbow		
26	20 ft	1" PVC conduit		
27	2 cn	PVC Cement – 1 quart / can		
28	10 rl	Vinyl tape: ¾" wide		
29	As required	PVC Permanent Cable Identification System, Numbers 0-9, Letters A-Z, PVC plastic identification system fixed to cable with wire ties		
II. Construction Materials				
30	300 ft	Conduit: 1.5" RGS electrical conduit		
31	50 ft	Conduit: 1.5" sch 80 PVC electrical conduit		
32	375 ft	Conduit: 2" RGS electrical conduit for Junction Box cables		
33	10 lb	Conduit sealing compound		
34	150 pc	Conduit Strap: PVC Wall mount		
35	150 pc	PVC wall anchor plug: 5/16"		
36	150 pc	5/16" x 1.5" L SS screw for wall anchors		
37	1 gal	2 part, fast set corrosion protection epoxy		
38	150 sets	SS fasteners, 1/4" 1 set = 3/8" x 1.5" bolt, nut, flat and lock washer for junction box mounting		
39	64 set	SS fasteners, 3/8" 1 set = 3/8" x 1.5" bolt, nut, flat and lock washer for negative cable to bracket connection		
40	12 no.	Steel bracket- 1" W x 6" L x ¼" T with 3 drilled 0.5" diameter holes, per detail 8		
41	4 no.	Steel 'L' bracket – 2" x ¼" plate. 4 inches H x 4" L (L-shape) bracket w, 3 x 0.5" drilled hole, per detail 9		
42	16 no.	Junction box support frame: Anode / Negative fabricated from 4" C-Channel – painted, with 12" x 12" x 24" concrete foundation, per detail 6 and 7.		
43	8 no.	Rectifier mounting frame: Fabricated from 4" C channel, Galvanized, with 60 L" x 30" W x 18" H concrete foundation. per detail 11		
44	As Req'd	Sand – Trench backfill		
45	30 no.	Ring Terminal Lug: No. 4 AWG with 7/16" dia. ring		
46	10 no.	Ring Terminal Lug: No. 2 AWG with 7/16" dia. ring		

47	10 no.	Ring Terminal Lug: No. 12 AWG with 7/16" dia. ring		
		TOTAL PRICE FOB PLANT	**US$**	
		INLAND FREIGHT & INSURANCE	**US$**	
		TOTAL PRICE – CNF DELTA UTAH WAREHOUSE	**US$**	

2.0 Construction Installation

Refer to Appendix E – Construction Scope of Work

Item	Activity	Estimated Quantity	Unit	Unit Rate (US$)	Total Price (US$)
1	Mobilization / Demobilization	1	Lot		
2	Install Transformer Rectifier Unit – see detail 11				
2a	Outdoor Frame Mount	8	no.		
2b	Indoor Wall Mount	8	no.		
3	Install Anode Groundbed – see detail 5	20	no.		
3a	Drilling per foot (170 and 190 ft depths)	3480	ft		
3b	Install 6" PVC Surface casing to 20 foot depth	20	no.		
3c	Assemble anodes, anode centralizer and vent pipe – load into drilled borehole,	20	no.		
3d	Install cokebreeze backfill by pump method from bottom to 5 feet above top anode in hole.	20	no.		
3e	Install 5 feet of PermaPlug casing sealer above cokebreeze column	20	no.		
3f	Backfill borehole with native soil from top of PermaPlug to 2 feet below surface grade elevation.		no.		
3g	Complete anode borehole: tie off anode cables on 1" PVC cross conduit inside top of surface casing, install 90 degree elbows on vent pipe, route anode cables out the side of the 6" surface casing to the anode junction box, install 6" end cap to 6"	20	no.		

	surface casing (do not cement), Provide concrete foundation around finished anode groundbed.				
4	Install Anode or Negative Junction Support Frame w/ concrete foundation – see detail 6 and 7	36	no.		
5	Install Reference Electrode – see detail 10	35	no.		
5a	Drill 4" diameter hole to pipe depth (9.5 to 22.5 feet) Drilling per foot	525 (Est.)	ft		
5b	Install test station above hole with concrete foundation, terminate reference lead wire on test station terminal board. See detail 1 and 2	35	no.		
6	Install Test Access Hole with concrete foundation – see detail 1 and 2	8	no.		
7	Trench and install cables- see details 3 and 4, and CP layout drawing, sheet 1 and 2 for locations. Trench depth is 18", install x as required width, install 1" sand in bottom trench before installation of cables and 1" of sand over top of cables, backfill trench with native soil and install 6" warning tape at 12" below grade. Cables to be routed in common trench wherever possible. (Final documented trenching length measurements will determine total cost)		-		
7a	Trenching, cable installation and backfill in soil	Estimate 4000 ft	ft		
7b	Trenching, cable installation and backfill in asphalt, repair of asphalt	Estimate 3000 ft	ft		
7b	Trenching, cable installation and backfill in concrete	Estimate 400 ft	ft		
8	Weld 1" x 6" bracket to existing manhole cover hinge on bottom hinge – see detail 8	12	no.		
9	Install 1.5" RGS conduit mounted to wall inside of manholes and instrument vaults – see detail 8 and Drawing sheets 1 and 2 for locations	12 locations Average depth 20 ft	no.		

10	Core a 2" diameter hole through the side of the manhole or instrument vault approximately 6" below grade level for cable entry into manholes	12	no.		
11	Cable Terminations – Connect terminal lugs to cable, connect cable to bracket /bus bar using stainless steel hardware – see detail 6, 7, 8 and details E thru I, coat bracket and cable connections with corrosion resistant epoxy	Est. 50	no.		
12	Thermite welding of cable to electrical ground connection 'T' type run/tap connection	4	no.		

APPENDIX G

CONSTRUCTION DRAWINGS

Risk of Pipe Failure and Repair Priorities for 84, 114, 120, and 144 Inch Diameter PCCP Circulating Water System Intermountain Power Service Corporation, Delta, Utah

prepared for

Intermountain Power Service Corp.
850 West Brushwellman Road
Delta, Utah 84624-9546

prepared by

Simpson Gumpertz & Heger Inc.
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Project 030351 11 September 2003
(Revised 6 January 2004)

SGH

Simpson Gumpertz & Heger Inc.
Consulting Engineers

Boston / San Francisco / Washington, DC

11 September 2003
(Revised 6 January 2004)

Mr. Jerry Hintze
Intermountain Power Service Corp.
850 West Brushwellman Road
Delta, Utah 84624-9546

Project 030351 – Risk of Pipe Failure and Repair Priorities for Unit 1 and Unit 2 Pipelines, Circulating Water System, Intermountain Power Generating Station, Delta, Utah

Subject: Report of the Risk of Pipe Failure and Repair Priorities

Dear Mr. Hintze:

Enclosed is the report of the analysis performed to determine the risk of failure and repair priorities for the 84, 114, 120, and 144 in. diameter prestressed concrete cylinder pipes (PCCP) with broken wires in the Circulating Water System of the Unit 1 and Unit 2 pipelines.

We have determined the failure risk and repair priority of each distressed pipe piece based on structural evaluations and our field inspection. For distressed pipes, we performed structural evaluation of the serviceability, damage, and strength limit states for the combined effects of maximum pressure (working pressure and working plus transient pressure), and earth load acting on the pipe, pipe and fluid weights, and the number of broken wires and their locations along the pipe length, as determined from the Remote Field Eddy Current/Transformer Coupling (RFEC/TC) inspection. We inspected two pipes to verify the results of the RFEC/TC inspection, and two additional pipes to check the condition of the pipes.

In this report, we have also recommended additional studies that need to be performed and a general repair approach. The details of the repair approach need to be developed.

Please review and comment.

Sincerely yours,

Rasko Ojdrovic

Rasko P. Ojdrovic, Staff Consultant
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Mehdi S. Zarghamee

Mehdi S. Zarghamee, Principal

Encl.

1. INTRODUCTION

This report summarizes the results of our analysis of the risk of pipe rupture and determination of repair priorities of the pipe designs when subjected to the expected maximum pressure in the Units 1 and 2 pipelines Circulating Water System (CWS). These pipelines range in diameter from 72 in. to 144 in. and are shown schematically in Figure 1.

We reviewed the results of the electromagnetic testing using Remote Field Eddy Current/Transformer Coupling (RFEC/TC) by the Pressure Pipe Inspections Company (PPIC) presented in their reports for these pipelines, dated April 2003 and March 2003, respectively, and the supplemental reports for pipelines of both units dated May 2003. RFEC/TC was used to identify the pipes with broken wires, and to identify the number of broken wires and to locate their longitudinal position along the pipe length. Broken wires appear in one or several zones denoted as broken wire zones (BWZs). A total of 372 pipes in Unit 1 and 420 pipes in Unit 2 were inspected. The results of inspection indicate that there are 116 pipes in Unit 1 (31.2%) and 144 pipes in Unit 2 (34.3%) with five or more broken wires.

Purpose. The purpose of this report is to determine the risk of pipe rupture and the repair priority of each distressed pipe. Distresses pipes are defined as those with five or more broken wires.

Scope. The scope of our work presented in this report includes the following:

- Review of the results of the electromagnetic test performed to determine the number and location of broken prestressing wires, and other available pipeline data listed below.
- Development of the failure risk curves for each distressed pipe design and its cover height presented in terms of pressures that produce different limit states for varying effective numbers of broken wires.
- Field inspection of two 120 in. diameter pipes with broken wires detected by RFEC/TC, and two 84 in. pipes removed from the line prior to RFEC/TC inspection for the extent of corrosion and condition of the pipe coating and prestressing wires outside of the zones of broken wires, especially in areas adjacent to such zones, and the extent of corrosion of the steel cylinder under wide cracks. (We could not inspect the condition of steel cylinder in 120 in. diameter pipes because of the high risk of inspection).
- Evaluation of the risk of failure and repair priority for each distressed pipe, based on the results of our analysis, and the field inspection of the pipe.

- In addition to the above scope, we also provide a preliminary discussion of repair approach.

2. METHOD OF APPROACH

The method of approach involves application of the simplified procedure for the analysis of risk of failure of PCCP with broken wires. This simplified procedure was developed for structural evaluation and failure risk analysis of PCCP, embedded cylinder type, with broken wires based on the results of the nonlinear finite-element analysis, hydrostatic pressure testing, and field inspection of PCCP with broken wires.

The risk of failure of pipes with broken wires is expressed in terms of the serviceability, damage and strength limit states discussed below. Hydrostatic pressure testing of pipes with broken wires was performed to verify the results of the analysis. We performed field inspection of PCCP with broken wires at several different sites to verify the condition of the pipes including number and location of broken wires, condition of wires adjacent to the BWZs, extent of core cracking, and the corrosion condition of the embedded steel cylinder.

The RFEC/TC inspection results do not include any uncertainties. We are using a procedure that accounts for uncertainties associated with the number of broken wires, as detected by the RFEC/TC for a BWZ in the middle or near the end of the pipe, and between multiple BWZs.

3. DOCUMENTS RECEIVED AND RELIED ON

We received and relied on the following documents:

- Black & Veatch Drawings 9255-9HRC-M4727 and M4728 (1982), "Yard Piping Details, Circ Water Turbine Area – Units 1 thru 4 Plan" and "Yard Piping Details, Circulating Water Pipelines, Cooling Towers Area – Unit 1 and 2," respectively, updated to show pipe numbers, station and number of broken wires.
- Ameron Pipe Design Drawings and Layout Sheets (1983), attached in Appendix 1.
- RB&G Engineering Inc. Geotechnical Investigation Report (2002), "Helper Cooling Tower Site."
- Centry Constructors and Engineers Calculations (2002), "Helper Tower Flow Balance North Side."
- PPIC RFEC/TC Testing Reports (2003), "Unit 1 Circulating Water Pipeline," "Unit 2 Circulating Water Pipeline," dated April 2003 and March 2003, respectively, and the supplemental reports for pipelines for both units dated May 2003.

4. ANALYSIS OF RISK OF FAILURE OF PCCP WITH BROKEN WIRES

The simplified procedure for the analysis of risk of failure of PCCP with broken wires requires structural evaluation of serviceability; damage and strength limit states for a pipe subjected to internal pressure, pipe and fluid weights, earth load, and prestressing force.

4.1 Earth Load, Pipe and Water Weight

The earth load is calculated based on the cover heights provided by you. We understand that the distance from ground surface to the centerline of the pipe is typically 16 ft, except that it is 26 ft under the upper parking lot (approximately from Sta. 164+00 to Sta. 167+00), 11 ft in the cooling tower area (approximately from Sta. 173+00 to the cooling towers), 9 ft for the 144 in. diameter pipelines, and 14 ft at the start of the supply lines near the pumping station.

The earth load and pipe and fluid weights are calculated using an Olander pressure distribution with a120° bedding angle for earth load and water weight and with a 15° bedding angle for pipe weight.

4.2 Maximum Pressure

The circulating water pipeline was designed for the working pressure, P_w, of 60 psi, and a test pressure of 72 psi. However, the actual working pressure is less. The working pressure along the pipeline was calculated by Centry Constructors and Engineers (2002) as a part of the design for the new Helper cooling tower. The calculation indicates that the working pressure is 36 psi at the start of the supply line, 27 psi at the end of the 120 in. diameter portion of the return line, and about 16 psi near the cooling towers. Based on these values we used the following working pressures:

- Supply line: P_w = 36 psi. (Segment B-72, B-120, B-84, and B-114).
- Return line to the end of 120 in. diameter portion: P_w = 32 psi. (Segments A-84-1, A-114 and A-120).
- Return line 84 in. diameter line downstream of 120 in. diameter portion: P_w = 27 psi. (Segments A-84-2 and A-84-3).
- Return line 144 in. diameter line from cooling towers to the pump station: P_w = 12 psi. (Segments C-144 and D-144).

The maximum working plus transient pressure in the line is not known at present, and it can be determined from a hydraulic surge analysis. We understand that there has been a pump trip in 1987 due to a blackout that resulted in transient pressures that reportedly shook the crossover lines off their foundations, but we do not know how high the maximum pressure was in the circulating water line. As a result of the 1987 event, emergency power improvements and controls were designed and installed to prevent blackout trip damage. It does not appear that there are any surge protection systems currently on the cooling water lines. In absence of the results of hydraulic transient analysis, in our risk assessment for pipe with broken wires, we have temporarily assumed that the transient pressure is 50% of the working pressure for the maximum pressure of P_{max} = 1.5 P_w. This assumption is arbitray and a proper surge analysis needs to be performed. Using this temporary assumption, the maximum pressures are as follows:

- Supply line: P_{max} = 54 psi. (Segments B-72, B-120, B-84 and B-114)
- Return line to the end of 120 in. diameter portion – P_{max} = 48 psi. (Segments A-84-1, A-114, and A-120)
- Return line 84 in. diameter line downstream of 120 in. diameter portion - P_{max} = 41 psi. (Segments A-84-2 and A-84-3)
- Return line 144 in. diameter line from cooling towers to the pump station: P_w = 18 psi. (Segments C-144 and D-144)

4.3 Limit States

The risk of failure of pipes with broken wires is expressed in terms of the limit states discussed below.

Serviceability Limit State: The pressure corresponding to the

- Onset of visible longitudinal cracking in the core.

Damage Limit State: These limit states can cause failure with time. The minimum pressure corresponding to

- Structural cracking, i.e., 13 mil crack width in the inner face of the outer core for pipes with a core thickness of 7 1/4 in. or less and 24 mil crack width for pipes with core thickness of 9 in. or more and linearly varying in between.
- Increase in wire stress adjacent to the prestress loss zone by 30 ksi.

Strength Limit State: The minimum pressure corresponding to

- Interlocking strength of cracked core with and without inclusion of soil resistance in the broken wire zone.
- Punching shear strength of outer core in the broken wire zone.

The effect of prestress loss on damage limit states is determined using the results of a linear elastic finite-element model of the pipe with single and multiple crack(s) at the springline in the outer core over the entire prestress loss area for each pipe design (Figure 2) and experimentally or analytically obtained modification factors that account for nonlinearities. The model is subjected to prestress load and the combined effects of internal pressure, earth load, and pipe and fluid weights. The results of the finite-element analyses were used to determine the limit-state pressures associated with the (1) designated crack width, and (2) wire stress change adjacent to the prestress loss zone (Figure 3). Prestress loss is modeled by removing the external pressure of the prestress over an entire band.

For the onset of cracking, we use the actual residual prestress and the strain theory developed for the design of PCCP for the onset of cracking as described in AWWA C304, assuming conservatively that there is no benefit from pipe stiffness outside of the BWZ.

Strength limit states are hand calculated with an experimentally and analytically obtained modification factor for the interlocking strength and punching shear strength of concrete outer core.

5. REPAIR PRIORITY ZONES

The above limit states divide the plots of pressure versus number of broken wires into zones as shown in Figures 4 through 12. Each zone is assigned an alphanumeric order, depending on the risk of pipe failure and the need for repair. The number of broken wires is based on the results of RFEC/TC technology. The repair priorities are as follows:

Priority 1: The maximum pressure in the line exceeds the pressure that produces the ultimate strength of the outer core and yielding of the steel cylinder. This priority is divided into three sub-priorities as follows:

Priority 1A – The maximum pressure exceeds the pressure that produces the ultimate strength of the outer core and yielding of the steel cylinder with soil resistance to the outward expansion of the pipe and the pressure that result in an increase in the wire stress of 60 ksi. Immediate repair is recommended.

Priority 1B – The maximum pressure exceeds the pressure that produces the ultimate strength of the outer core and yielding of the steel cylinder without consideration of soil resistance or wire stress increase. Soil resistance alone prevents pipe failure. Immediate repair is recommended.

Priority 1C – The maximum pressure exceeds the pressure that produces the ultimate strength of the outer core and yielding of the steel cylinder without consideration of soil resistance or wire stress increase, but it is less than the pressure resulting in the ultimate strength of an uncorroded steel cylinder.

Failure can occur with time as the steel cylinder corrodes. Repair should be performed within a very short time period.

Priority 2: The maximum pressure exceeds the pressure that causes structural cracking and results in an increase in the wire stress of 30 ksi or more, but is less than the pressure that produces the ultimate strength limit states (Priority 1). The failure occurs with time as the steel cylinder, exposed to the environment by wide structural cracks, corrodes. This priority is subdivided into two sub-priorities as follows:

Priority 2A – The maximum pressure also exceeds the ultimate strength of uncorroded steel cylinder. Repair should be performed within a short time period.

Priority 2B – The maximum pressure is less than the ultimate strength of uncorroded steel cylinder limit state. The condition of the steel cylinder under core cracks should be determined within a short time period. Repair should be performed as needed depending on the expected rate of corrosion and the condition of the steel cylinder. Pipeline should be inspected within three to five years.

Priority 3 The maximum pressure in the line exceeds the onset of core cracking limit state, but not the structural cracking limit state. The failure of the pipe, if it occurs at all, is after much longer time period than in Priority 2. This priority is subdivided into two sub–priorities as follows:

Priority 3A – The maximum pressure also exceeds the ultimate strength of uncorroded steel cylinder limit state. Pipeline should be inspected in five years. In some applications, the uncertainty in RFEC and in surge pressure, the consequence of failure at the high pressures involved requires upgrading the priority of failure of all or some of the pipes in this region to 2B.

Priority 3B – The maximum pressure is less than the ultimate strength of uncorroded steel cylinder limit state. Pipeline should be inspected again within five to ten years.

Priority 4: The maximum pressure in the line is less than the onset of cracking limit state. The failure of the pipe is not expected. This priority is also subdivided into two sub–priorities as follows:

Priority 4A – The maximum pressure exceeds the ultimate strength of uncorroded steel cylinder limit state.

Priority 4B – The maximum pressure is less than the ultimate strength of uncorroded steel cylinder limit state. Cracking is not expected, but if it occurs, the steel cylinder strength alone exceeds the maximum pressure.

6. PIPE REPAIR PRIORITIES

6.1 Pipe with Single Break Area

The risk of pipe rupture and repair priorities of different pipe designs in the pipeline should be determined from the number of wire breaks and the maximum pressure in the pipe. Considering the accuracy of the RFEC/TC, it is prudent to evaluate repair priorities using an effective number of broken wires, N_e, equal to the actual number of broken wires as determined from RFEC/TC, N, plus a certain number of wires that account for the error in RFEC/TC and for wires that may be severely corroded but are electrically continuous to account for uncertainty in the number of broken wires determined from RFEC/TC test, and a number of wires that may break by the time of the next inspection or of the pipe repair.

Uncertainty in RFEC/TC results. RFEC/TC accuracy is discussed in the PPIC reports. In general, accuracy is less near the joints and in pipes with multiple wire break zones. The results are given in increments of five broken wires and the locations of wire breaks are given to the nearest 6 in. In addition, some wires adjacent to the broken wires may be severely corroded but are electrically continuous and, therefore, do not show as broken in an RFEC/TC inspection. To account for both these effects, we denote a length of uncertainty as L_c. Based on the severely corroded prestressing wires observed on a small sample of pipes in our inspection described below, we recommend that it would be prudent to assume that additional 6 in. of nearly broken wires may exist around a BWZ, i.e., 3 in. on each side of the BWZ. This assumption, accounting for uncertainties in RFEC/TC inspection is conservative for most of the pipes, but it may be appropriate for a small number of pipes in the line.

Increase in BWZ over time. We understand that you will not be able to repair the pipes within at least one to two years. We therefore consider the annual rate of growth of BWZ to account for wire breakage that may take place until the time of either the next inspection or pipe repair. Since this was the first RFEC/TC inspection, there is no information available on the rate of growth of BWZ, denoted L_r (in./year). The supply and return lines operate at different temperatures, and there are significantly more distressed pipes on the warmer return lines, including pipes that have virtually all wires broken. For the return lines, we recommend using L_r = 6 in./year for a BWZ, i.e., 3 in. on each side of BWZ, considering that there is a significant number of pipes with a large number of broken wires and advanced corrosion. For the supply lines, we recommend using L_r = 3 in./year, 1-1/2 in. on each side of BWZ. Note that the rate of growth of BWZ is likely faster for pipes with more broken wires than for the pipes with smaller number of broken wires. Once the rate of growth of BWZ is established by subsequent

RFEC/TC testing, it can be used to improve the prediction of the effective number of broken wires with time. We recommend using 3 years to calculate the effective number of broken wires, assuming that the pipes will either be repaired or that another inspection will take place within that time frame.

Effective number of broken wires. The effective number of broken wires after t years before the next scheduled inspection or pipe repair is calculated for a pipe with n_w number of wraps per foot as follows:

$$N_{et} = N_e + t\ n_w\ L_r = N + n_w\,(L_c + t\ L_r) = N + n_w\ L_x$$

where $L_x = L_c + t\ L_r$.

6.2 Pipe with Multiple Wire Break Zones

For pipes with multiple broken wire zones, interaction of two BWZ on a pipe should be based on the number of broken wires N_1 and N_2 and the actual clear distance between them Λ in inches (in.) and the minimum clear distance required is C in inches. For a typical ECP, the value of C is approximately equal to about $D_i/20$ and D_i = internal diameter in inches. The interaction between the two BWZ depends on the structural interaction of the two zones which depends on the pipe diameter, and uncertainty in the number of broken wires and the rate of growth in the number of broken wires discussed above. We recommend the following criteria for calculation of the effective number of broken wires N_{et}:

If $\Lambda < C + L_X$ and if N_1 and $N_2 \geq \min\left(10, \frac{n_w C}{12}\right)$, then the two BWZs are combined and

$$N_{et} = N'_{et}$$

If $C + L_X \leq \Lambda \leq 2C + L_X$ and if N_1 and $N_2 \geq \min\left(10, \frac{n_w C}{12}\right)$, then the two BWZs interact partially

and $$N_{et} = \frac{2C + L_x - \Lambda}{C} N'_e + \frac{\Lambda - C - L_x}{C} N''_{et}$$

If $\Lambda > 2C + L_X$, then the two zones are separate and

$$N_{et} = N''_{et}$$

where $$N'_{et} = N_1 + N_2 + \frac{n_w \Lambda}{12} + L_X\ n_w$$

$$N''_{et} = \max(N_1, N_2) + L_X\ n_w$$

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6.3 Pipe with Wire Break Zone Near Ends

RFEC may have a reduced accuracy near the pipe ends. For pipes where broken wire zones end near a joint, we recommend to increase the number of broken wires to include the effect of possibly broken wires near the joint over a length L_j in a manner similar to that used for pipes with multiple broken wire zones, while treating the joint as a virtual broken wire zones, i.e., if N_1 is the corresponding number of broken wires and if Λ denotes the clear distance to the joint, then

If $\Lambda < C + L_{xj}$ and $N_1 \geq \min\left(10, \frac{n_w C}{12}\right)$, then the BWZ extends to the joint and

$$N_{ej} = N'_{ej}$$

If $C + L_{xj} \leq \Lambda \leq 2C + L_{xj}$ and $N_1 \geq \min\left(10, \frac{n_w C}{12}\right)$, then the BWZ and the joint partially interact and

$$N_{ej} = \frac{2C + L_{xj} - \Lambda}{C} N'_{ej} + \frac{\Lambda - C - L_{xj}}{C} N''_{ej}$$

If $\Lambda > 2C + L_{xj}$, then the BWZ does not extend to the joint and

$$N_{ej} = N''_{ej}$$

where $N'_{ej} = N_1 + \frac{n_w \Lambda}{12} + L_{xj}\, n_w$

and $N''_{ej} = N_1 + L_{xj}\ N_w$

$$L_{xj} = 0.5\, L_x + L_j$$

where L_j = length of possibly broken wires near a joint not detected by RFEC/TC due to lack of accuracy near a joint. At this time, we recommend using L_j = 12 in.

6.4 Repair Priority

The results of RFEC/TC and the pipe repair priorities are given in Tables A1 and A2 in Appendix 2 (we used the same pipe numbers, stations, and notation for pipeline segments as in the PPIC reports). The repair priorities in Table A1 are given for both the working plus transient and the working pressures and the effective number of broken wires at present (t = 0). The repair priorities in Table A2 are given for both the working plus transient pressure and the working pressures, and the effective number of broken wires expected in three years. The number of pipes in different repair priorities in all pipeline segments for Units 1 and 2 are summarized in Tables 1 and 2 below. The tables present the results at present and in three

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years for a pipeline operated under the working pressures, and under the assumed working plus transient pressures described earlier.

Table 1A-1 – Number of Pipes in Different Repair Priorities at Present – Unit 1 (P = Pw)

Pipe	Priority										
Design	1a	1b	1c	2a	2b	3a	3b	4a	4b	Total	Inspected
A-84-1	0	0	0	0	2	0	0	0	1	3	5
A-114	0	0	0	0	1	0	1	0	0	2	6
A-120	0	0	0	0	21	0	10	0	46	77	127
A-84-2	0	0	0	0	0	0	0	0	1	1	12
A-84-3	0	0	0	0	7	0	0	0	4	11	31
B-72-2	0	0	0	0	0	0	0	0	0	0	3
B-72-3	0	0	0	0	0	0	0	0	0	0	2
B-84	0	0	0	0	0	0	0	0	0	0	6
B-114	0	0	0	0	0	0	1	0	0	1	8
B-120	0	0	0	0	0	0	1	0	19	20	109
C-144	0	0	0	0	0	0	0	0	1	1	50
D-144	0	0	0	0	0	0	0	0	0	0	13
Total	*0*	*0*	*0*	*0*	31	*0*	13	*0*	*72*	116	372
% of Inspected	0.0%	0.0%	0.0%	0.0%	8.3%	0.0%	3.5%	0.0%	19.4%	31.2%	100.0%

Table 1A-2 – Number of Pipes in Different Repair Priorities at Present – Unit 1 (P = Pw + Pt)

Pipe	Priority										
Design	1a	1b	1c	2a	2b	3a	3b	4a	4b	Total	Inspected
A-84-1	0	0	1	0	1	0	1	0	0	3	5
A-114	0	1	0	0	0	1	0	0	0	2	6
A-120	1	17	0	9	0	22	1	23	4	77	127
A-84-2	0	0	0	0	0	0	0	0	1	1	12
A-84-3	0	0	0	0	7	0	2	0	2	11	31
B-72-2	0	0	0	0	0	0	0	0	0	0	3
B-72-3	0	0	0	0	0	0	0	0	0	0	2
B-84	0	0	0	0	0	0	0	0	0	0	6
B-114	0	0	0	1	0	0	0	0	0	1	8
B-120	0	0	0	0	0	5	0	15	0	20	109
C-144	0	0	0	0	0	0	0	0	1	1	50
D-144	0	0	0	0	0	0	0	0	0	0	13
Total	1	18	1	10	8	28	4	38	8	116	372
% of Inspected	0.3%	4.8%	0.3%	2.7%	2.2%	7.5%	1.1%	10.2%	2.2%	31.2%	100.0%

Table 1B-1 – Number of Pipes in Different Repair Priorities in Three Years– Unit 1 (P = Pw)

Pipe	Priority										
Design	1a	1b	1c	2a	2b	3a	3b	4a	4b	Total	Inspected
A-84-1	0	0	0	0	3	0	0	0	0	3	5
A-114	0	0	0	0	2	0	0	0	0	2	6
A-120	0	0	0	0	34	0	21	0	22	77	127
A-84-2	0	0	0	0	0	0	1	0	0	1	12
A-84-3	0	0	0	0	9	0	0	0	2	11	31
B-72-2	0	0	0	0	0	0	0	0	0	0	3
B-72-3	0	0	0	0	0	0	0	0	0	0	2
B-84	0	0	0	0	0	0	0	0	0	0	6
B-114	0	0	0	0	0	0	1	0	0	1	8
B-120	0	0	0	0	0	0	4	0	16	20	109
C-144	0	0	0	0	0	0	0	0	1	1	50
D-144	0	0	0	0	0	0	0	0	0	0	13
Total	0	0	0	0	48	0	27	0	41	116	372
% of Inspected	0.0%	0.0%	0.0%	0.0%	12.9%	0.0%	7.3%	0.0%	11.0%	31.2%	100.0%

Table 1B-2 – Number of Pipes in Different Repair Priorities in Three Years– Unit 1 (P = Pw + Pt)

Pipe Design	Priority 1a	1b	1c	2a	2b	3a	3b	4a	4b	Total	Inspected
A-84-1	0	0	1	0	2	0	0	0	0	3	5
A-114	0	2	0	0	0	0	0	0	0	2	6
A-120	5	18	0	20	0	21	1	8	4	77	127
A-84-2	0	0	0	0	0	0	1	0	0	1	12
A-84-3	0	0	0	0	9	0	0	0	2	11	31
B-72-2	0	0	0	0	0	0	0	0	0	0	3
B-72-3	0	0	0	0	0	0	0	0	0	0	2
B-84	0	0	0	0	0	0	0	0	0	0	6
B-114	0	0	0	1	0	0	0	0	0	1	8
B-120	0	0	0	1	0	5	0	14	0	20	109
C-144	0	0	0	0	0	0	0	0	1	1	50
D-144	0	0	0	0	0	0	0	0	0	0	13
Total	**5**	**20**	**1**	**22**	**11**	**26**	**2**	**22**	**7**	**116**	**372**
% of Inspected	**1.3%**	**5.4%**	**0.3%**	**5.9%**	**3.0%**	**7.0%**	**0.5%**	**5.9%**	**1.9%**	**31.2%**	**100.0%**

Table 2A-1 – Number of Pipes in Different Repair Priorities at Present – Unit 2 (P = Pw)

Pipe Design	Priority 1a	1b	1c	2a	2b	3a	3b	4a	4b	Total	Inspected
A-84-1	0	0	0	0	3	0	2	0	0	5	9
A-114	0	0	0	0	1	0	1	0	3	5	9
A-120	0	0	0	0	24	0	24	0	37	85	139
A-84-2	0	0	0	0	1	0	0	0	0	1	11
A-84-3	0	0	0	0	18	0	0	0	1	19	31
B-72-1	0	0	0	0	0	0	0	0	0	0	2
B-72-2	0	0	0	0	0	0	0	0	0	0	3
B-72-3	0	0	0	0	0	0	0	0	0	0	4
B-84-1	0	0	0	0	0	0	1	0	0	1	10
B-114	0	0	0	0	0	0	1	0	2	3	11
B-120	0	0	0	0	0	0	5	0	20	25	133
C-144	0	0	0	0	0	0	0	0	0	0	48
D-144	0	0	0	0	0	0	0	0	0	0	10
Total	**0**	**0**	**0**	**0**	**47**	**0**	**34**	**0**	**63**	**144**	**420**
% of Inspected	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**11.2%**	**0.0%**	**8.1%**	**0.0%**	**15.0%**	**34.3%**	**100.0%**

Table 2A-2 – Number of Pipes in Different Repair Priorities at Present – Unit 2 (P = Pw + Pt)

Pipe Design	Priority 1a	1b	1c	2a	2b	3a	3b	4a	4b	Total	Inspected
A-84-1	0	0	2	0	3	0	0	0	0	5	9
A-114	0	0	0	1	0	2	0	2	0	5	9
A-120	2	16	0	12	0	33	2	18	2	85	139
A-84-2	0	0	0	0	1	0	0	0	0	1	11
A-84-3	0	0	0	0	18	0	0	0	1	19	31
B-72-1	0	0	0	0	0	0	0	0	0	0	2
B-72-2	0	0	0	0	0	0	0	0	0	0	3
B-72-3	0	0	0	0	0	0	0	0	0	0	4
B-84-1	0	0	0	0	0	0	1	0	0	1	10
B-114	0	0	0	0	0	2	0	1	0	3	11
B-120	0	0	0	0	0	12	0	13	0	25	133
C-144	0	0	0	0	0	0	0	0	0	0	48
D-144	0	0	0	0	0	0	0	0	0	0	10
Total	**2**	**16**	**2**	**13**	**22**	**49**	**3**	**34**	**3**	**144**	**420**
% of Inspected	**0.5%**	**3.8%**	**0.5%**	**3.1%**	**5.2%**	**11.7%**	**0.7%**	**8.1%**	**0.7%**	**34.3%**	**100.0%**

Table 2B-1 – Number of Pipes in Different Repair Priorities in Three Years– Unit 2 (P = Pw)

Pipe	Priority										
Design	1a	1b	1c	2a	2b	3a	3b	4a	4b	Total	Inspected
A-84-1	0	0	0	0	5	0	0	0	0	5	9
A-114	0	0	0	0	2	0	1	0	2	5	9
A-120	0	0	0	0	39	0	31	0	15	85	139
A-84-2	0	0	0	0	1	0	0	0	0	1	11
A-84-3	0	0	0	0	18	0	1	0	0	19	31
B-72-1	0	0	0	0	0	0	0	0	0	0	2
B-72-2	0	0	0	0	0	0	0	0	0	0	3
B-72-3	0	0	0	0	0	0	0	0	0	0	4
B-84-1	0	0	0	0	0	0	1	0	0	1	10
B-114	0	0	0	0	0	0	2	0	1	3	11
B-120	0	0	0	0	2	0	10	0	13	25	133
C-144	0	0	0	0	0	0	0	0	0	0	48
D-144	0	0	0	0	0	0	0	0	0	0	10
Total	0	0	0	0	67	0	46	0	31	144	420
% of Inspected	0.0%	0.0%	0.0%	0.0%	16.0%	0.0%	11.0%	0.0%	7.4%	34.3%	100.0%

Table 2B-2 – Number of Pipes in Different Repair Priorities in Three Years– Unit 2 (P = Pw + Pt)

Pipe	Priority										
Design	1a	1b	1c	2a	2b	3a	3b	4a	4b	Total	Inspected
A-84-1	0	0	2	0	3	0	0	0	0	5	9
A-114	0	0	0	2	0	1	0	2	0	5	9
A-120	5	22	0	25	1	19	3	10	0	85	139
A-84-2	0	0	0	0	1	0	0	0	0	1	11
A-84-3	0	0	0	0	19	0	0	0	0	19	31
B-72-1	0	0	0	0	0	0	0	0	0	0	2
B-72-2	0	0	0	0	0	0	0	0	0	0	3
B-72-3	0	0	0	0	0	0	0	0	0	0	4
B-84-1	0	0	0	0	1	0	0	0	0	1	10
B-114	0	0	0	0	0	3	0	0	0	3	11
B-120	0	0	0	4	0	11	0	10	0	25	133
C-144	0	0	0	0	0	0	0	0	0	0	48
D-144	0	0	0	0	0	0	0	0	0	0	10
Total	5	22	2	31	25	34	3	22	0	144	420
% of Inspected	1.2%	5.2%	0.5%	7.4%	6.0%	8.1%	0.7%	5.2%	0.0%	34.3%	100.0%

The results indicate the following:

- Under the working pressure alone, the highest repair priority is 2B.
- Under working plus transient pressure, there are forty pipes in Priority 1, twenty-three pipes in Priority 2a, thirty pipes in Priority 2b, seventy-seven pipes in Priority 3a, seven pipes in Priority 3b, and eighty-three pipes in Priority 4.
- We estimate that after three years, the number of pipes may increase to fifty-five in Priority 1, fifty-three in Priority 2a, and thirty-six in Priority 2b
- Of the sixty-three pipes in Priorities 1 and 2a that require most immediate repairs, fifty-seven pipes (90.5%) are located in the A-120 portions of the return lines for Unit 1 and Unit 2.

7. FIELD INSPECTION

The purpose of the field inspection is to validate the results of RFEC/TC, to examine the condition of pipes with broken wires, to examine the condition of the steel cylinder, and to verify the risk of failure predictions determined by our risk analysis of pipes with broken wires, based on the observed condition of the pipe.

The scope of our inspection included inspection of two 120 in. diameter pipes in Unit 2 pipeline with broken wires detected by RFEC/TC, and inspection of two 84 in. diameter pipes with broken wires, removed from the line prior to RFEC/TC inspection and stored outside.

7.1 Inspection Procedure

The 120 in. diameter pipes were excavated for repairs and brush cleaned. The 84 in. pipes were stored in the yard. The inspection was performed by Dr. Rasko Ojdrovic of Simpson Gumpertz & Heger Inc. on 11 and 12 November 2003.

The inspection included marking the location of the zones with broken prestressing wires identified by RFEC/TC on 120 in. pipes on the coating based on the measurements from the center of pipe joints, sounding of the coating using a 1 lb to 2 lb hammer, and visual inspection of the coating for cracks, and corrosion stains and other anomalies. The defects were recorded in the inspection sheets previously prepared for each pipe (Appendix 3). The inspection also included opening windows in the coating to examine the condition of the prestressing wires and the concrete core. Windows for inspection of wires were typically opened in the middle of large BWZ, outside of the reported BWZ, near the end of the cracks extending beyond the BWZ, and between the two reported BWZ. We opened two windows in the concrete core of 84 in. diameter pipes removed from the line, but we did not open any windows in concrete core of 120 in. diameter pipes to examine the condition of the steel cylinder, because the pipeline was full of water, under pressure, and the risk of damage to the steel cylinder was high.

7.2 Results of Inspections

We inspected two 84 in. diameter pipes and two 120 in. diameter pipes. We do not have the RFEC/TC results for 84 in. pipes, and we do not know if the pipes had deteriorated since they were removed from the ground earlier this year. Photographs and descriptions of observed anomalies are shown in Photos 1 to 38. The pipe number, side, and the extent of the BWZ or hollow sounding and/or cracked coating are marked on the pipes using spray paint.

84 in. Pipe Number 427 (Photos 1 through 12): This pipe has not been inspected by RFEC/TC. On the exposed side of the pipe, we observed on the coating six areas of coating anomalies including coating cracks and hollow-sounding coating, ranging in length from 12 in. to 34 in. (Photo 2) The other side of the pipe was adjacent to Pipe 476 and could not be inspected. All areas with coating anomalies were located near the springline. (The pipe was laying on the ground in similar position as it was in the soil with springlines on the pipe sides.) Prestressing wires were corroded and disintegrated under the hollow sounding and cracked coating (Photos 3 through 9). The area of hollow-sounding coating was greater than the area of corroded and broken wires. We did not observe any longitudinal core cracks, but we observed a circumferential crack in the core, about 0.005 in. to 0.007 in. wide (Photo 10) located about 43 in. from the welded joint to a 45° elbow, on the outer side of the elbow. This crack was likely caused by a thrust resulting from internal pressure at the bend. (It is less likely that it was caused during removal of the pipe from the line since the elbow was cut to facilitate pipe removal.) A piece of the core was removed and no corrosion was observed on the exposed steel cylinder under the crack (Photos 11 and 12).

84 in. Pipe Number 476 (Photos 13 through 18): This pipe has not been inspected by RFEC/TC. We observed two areas of broken wires: an approximately 12 ft-8 in. long segment of coating and prestressing wires had spalled from the end of the pipe near the end close to a 45° elbow (Photos 13 and 14), and an approximately 4 ft long area near the other end of the pipe (Photo 16). Some coating pieces were observed under the pipe and some coating may have spalled when the pipe was moved. There was an approximately 1/8 in. wide crack in the core along the length of the BWZ (Photos 14 and 15). A piece of the core was removed to expose the steel cylinder, and only minor surface corrosion was observed on the steel cylinder (Photos 17 and 18).

120 in. Pipe Number 597 (Photos 19 through 31): The RFEC/TC inspection indicated that the pipe has two BWZ, eighty broken wires in each BWZ about 3.5 ft long, separated by about 5 in. We observed the coating crack and hollow sounding coating extending between the two BWZ on the northeast side of the pipe. The prestressing wires were fully corroded and disintegrated within the BWZ and between the two BWZ. The effective length of BWZ near the springline was about 6.5 ft, and corroded wires extended toward the invert. Near the middle of the BWZ, we observed a 0.015 in. wide crack in the core (Photos 24 and 25). On the other side of the pipe, the effective length of BWZ is about 4 ft and we did not observe any crack in the core (Photos 30 and 31).

120 in. Pipe Number 598 (Photos 32 through 38): This pipe has 325 broken wires along the entire length as determined by RFEC/TC inspection. We observed large longitudinal cracks spaced at about 6 in. to 12 in. and hollow-sounding coating (Photos 32 and 33). The prestressing wires are fully corroded and disintegrated under the coating. Near the pipe springline, we observed one 0.060 in. wide crack in the core (Photos 35 through 38). We did not observe any other longitudinal or circumferential cracks. We could not examine the condition of the cylinder since the risk of damage to the cylinder was not acceptable. We did not observe signs of corrosion stains emanating from the crack.

In addition to the four PCCPs, we observed the condition of the steel plates in two 84 in. diameter elbows. The steel plates were heavily corroded with significant scaling. We did not measure the loss of section or the remaining thickness of the steel in elbows, and we understand that you intend to measure the remaining thickness of steel in the two elbows excavated.

7.3 Summary of Field Inspection Results

We inspected only two 120 in. diameter pipes with broken wires identified by RFEC/TC. This is a small and inadequate sample to derive any general conclusions about the accuracy of RFEC/TC, condition of wires adjacent to the BWZ, or condition of the steel cylinder. We could not observe the condition of the steel cylinder because the pipeline was under pressure and the risk of damage to the cylinder was high. Both inspected pipes had corroded and broken prestressing wires in the areas identified by RFEC/TC: one pipe had broken wires along its entire length, and the other pipe had 80 broken wire areas (about 3.5 ft long) in two zones separated by about 5 in.; however, the two BWZs were in fact connected as the wires in between the BWZs were broken. Corrosion of prestressing wires is expansive and causes spalling and cracking of the coating, which makes the wires adjacent to BWZs exposed to corrosion and breakage. The observed cracks in the concrete core correlated well with the expected cracks based on our analysis and risk of failure curves (Figures 13 and 14). Internal pressure likely caused circumferential cracking of the 84 in. diameter pipes located near a 45° elbow.

8. DISCUSSION

The results of RFEC/TC indicate that there are significantly more broken wires in the return lines for Units 1 and 2 than in the supply lines. The return lines likely deteriorated more because of the temperature higher by about 20°F than in the supply line (supply line operates at about 90°F, and return line operates at about 109°F). Higher operating temperature accelerates corrosion of prestressing wires and the steel cylinder.

The working pressure is lower than the pressure that would cause rupture of the uncorroded steel cylinder, and the working plus transient pressure is slightly higher, except for the 84 in. diameter portion of the lines. The return line is at a lower working and working plus transient pressure than the supply line. In pipes with broken prestressing wires, the resistance to failure is provided by the steel cylinder, by the concrete core that is likely cracked, and by the surrounding soil. As the steel cylinder corrodes, it may develop pinholes and leakage that will lead to accelerated corrosion, erosion of soil support, and ultimately pipe failure. If the pressure is sufficiently low, the pipe may continue to operate without failure and when all prestressing wires are broken and even some of the steel cylinder thickness is lost to corrosion.

While there are no known leaks at present, condition of the steel cylinder is not known. We found the cylinder to be clean under the cracks in the 84 in. pipes, one as wide as 1/8 in., and we observed no corrosion stains emanating from the cracks in 120 in. pipes, but it is possible that the cylinder is corroded and that there are pipes in the line with corroded steel cylinders. The steel plate at 84 in. elbows removed from the line had significant corrosion. On other pipelines we have observed corrosion of steel cylinder under much narrower cracks, as wide as 0.030 in wide. In case steel cylinder is corroded, the repair priorities may be unconservative, as they are based on the assumption that the steel cylinder has not yet lost thickness to corrosion. Another parameter that may affect the repair priority of a pipe is interaction of adjacent zones of broken wires. We made assumptions on interaction of multiple zones with broken wires, based on our observations on other pipelines and on a very small sample of pipes on this pipeline, as described above.

Circumferential cracking of core due to pressure induced thrust may cause steel cylinder yielding, corrosion, leakage, loss of soil support, and ultimately pipe failure. Condition of pipes near elbows should be investigated further by internal inspection, and externally if needed.

9. REPAIR OR REPLACEMENT OPTIONS TO INCREASE PIPELINE RELIABILITY

Pipeline life can be increased by reducing the maximum pressure, reducing the rate of corrosion through cathodic protection, repair of individual corroded pipe pieces, lining or replacing distressed pipe pieces or parts of the lines. The best suited options depend on the condition of the steel cylinder, cost, and the expected reliability of the pipeline.

The pipelines operate under a sufficiently high maximum pressure that some pipes may rupture without any corrosion of the steel cylinder if there are a large number of broken wires; for other pipes, steel cylinder corrosion is needed to rupture the pipe. Therefore, reduction of the maximum surge pressure could increase the life of the pipelines significantly.

Cathodic protection (CP) is the least expensive repair option and it can be applied on this electrically continuous line on both supply and return lines. CP does not eliminate the corrosion, and thus the chance of failure, but it can reduce the corrosion rate significantly. Many of the pipes in these lines have low maximum pressure, less than the strength of the pipe with all wires broken. If the steel cylinder is not corroded, such pipes have low repair priority and their repair can be delayed with application of CP. (Note that incorrectly applied CP has had disastrous effects on PCCP lines.)

Pipes with broken wires are isolated individual occurrences in the supply line; whereas, in the return line the distressed pipes are more clustered. Since the pressure and the grouping of the distressed pipes in the supply and return lines are different, the preferred repair options may be different.

- Repair of individual distressed pipe pieces as in the supply line and parts of return line may be performed by either post-tensioning from the outside or by application of carbon fiber reinforce plastic (CFRP) wrap from the inside. In most cases where cover height is in the range of 6 to 10 ft, the post-tensioning repair is less expensive. Excessive cover height or proximity to other utilities or structures necessitates cost-evaluation of different repair options. Post-tensioning repair can be done with the pipe full of water and even under some small pressure, depending on the corrosion condition of the steel cylinder.
- Repair of several adjacent distressed pipe pieces (as in portions of the return line) may be performed by pipe replacement or lining of distressed pieces with either steel or fiberglass pipe liners. An advantage of a liner is that a deteriorated portion of the line may be repaired at once, while the disadvantages include reduction in pipe diameter, longer down time, and higher initial cost of lining.

Considering the distribution of pipes with broken wires, the most cost effective repair for the cooling water lines appears to be repair of the individual pipe pieces using either post tensioning or internal carbon fiber reinforced plastic lining. Portions of the 120 in. diameter portions of the return with significant number of pipes in priorities 1 and 2 may be considered for lining repair.

10. RECOMMENDATIONS

Our recommendations, based on information we have received and extent of limited inspection we have performed, are as follows:

- Repair Priority 1 and Priority 2a pipes as soon as possible. Repair of Priority 2a pipes may be delayed if there are significant time constraints. but we prefer that attempts be made to repair Priority 2a segments in the near future (less than three years). Priority 2b and Priority 3 pipeline segments should be inspected and/or monitored, and should be repaired in the future as needed.
- Inspect the condition of the steel cylinder during the first outage on five pipes of different size in Priorities 1 and 2 under wide cracks to determine the extent of corrosion.
- Inspect all pipes near the elbows internally, and if needed, externally to verify if pressure-induced thrust has caused circumferential cracking of the pipe core.
- Identify repair options and develop repair design procedures for the Priority 1 and 2 pipes.
- Perform a feasibility study to apply cathodic protection to the pipeline. The feasibility study should be based on the corrosion condition of the steel cylinders.
- Install pressure gages at several locations along the pipelines to measure working and working plus transient pressures.
- Develop a model for transient surge analysis and develop measures to reduce transient pressures.

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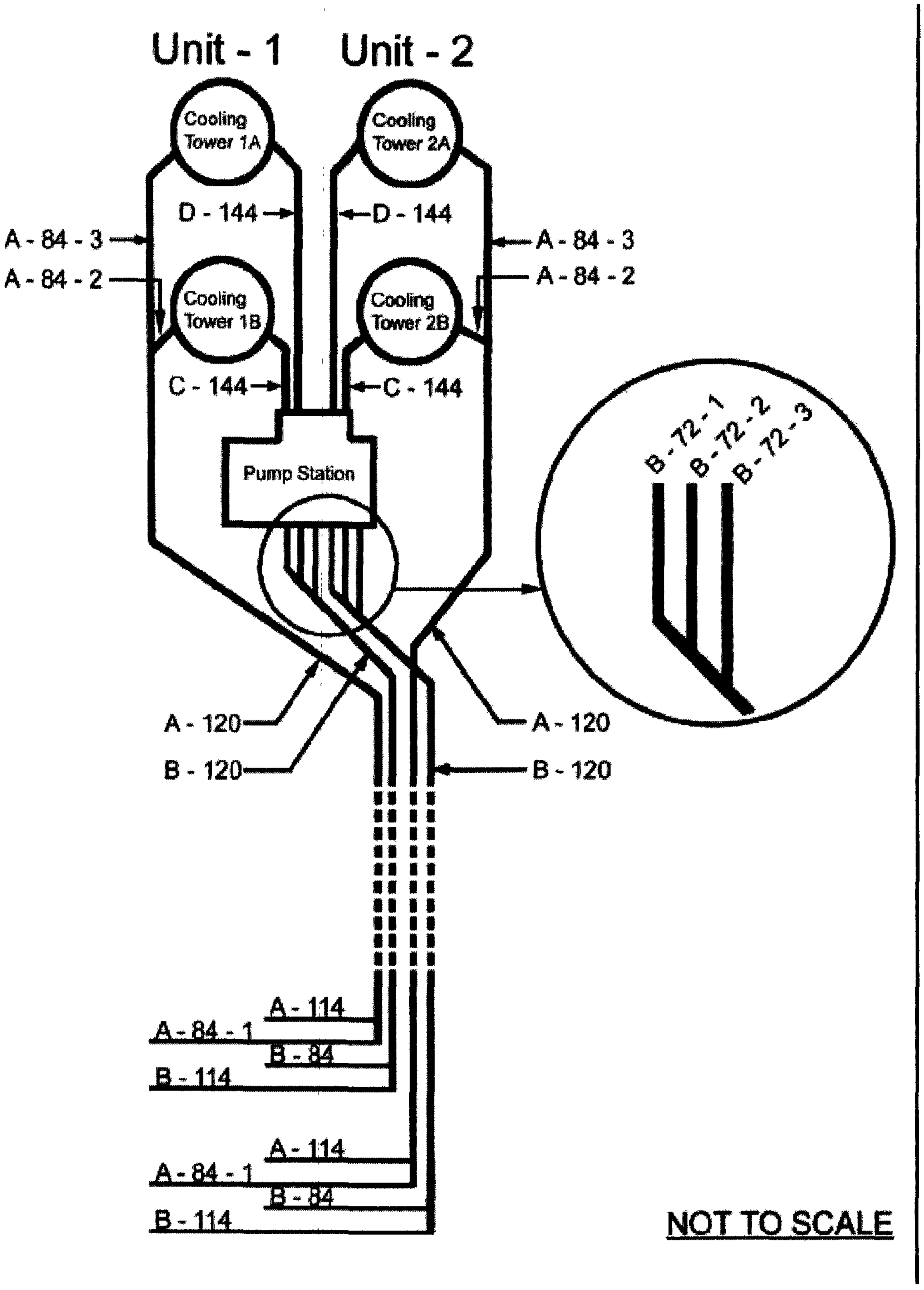

Figure 1 – Schematic Diagram of Circulating Cooling Water Pipelines for Units 1 and 2

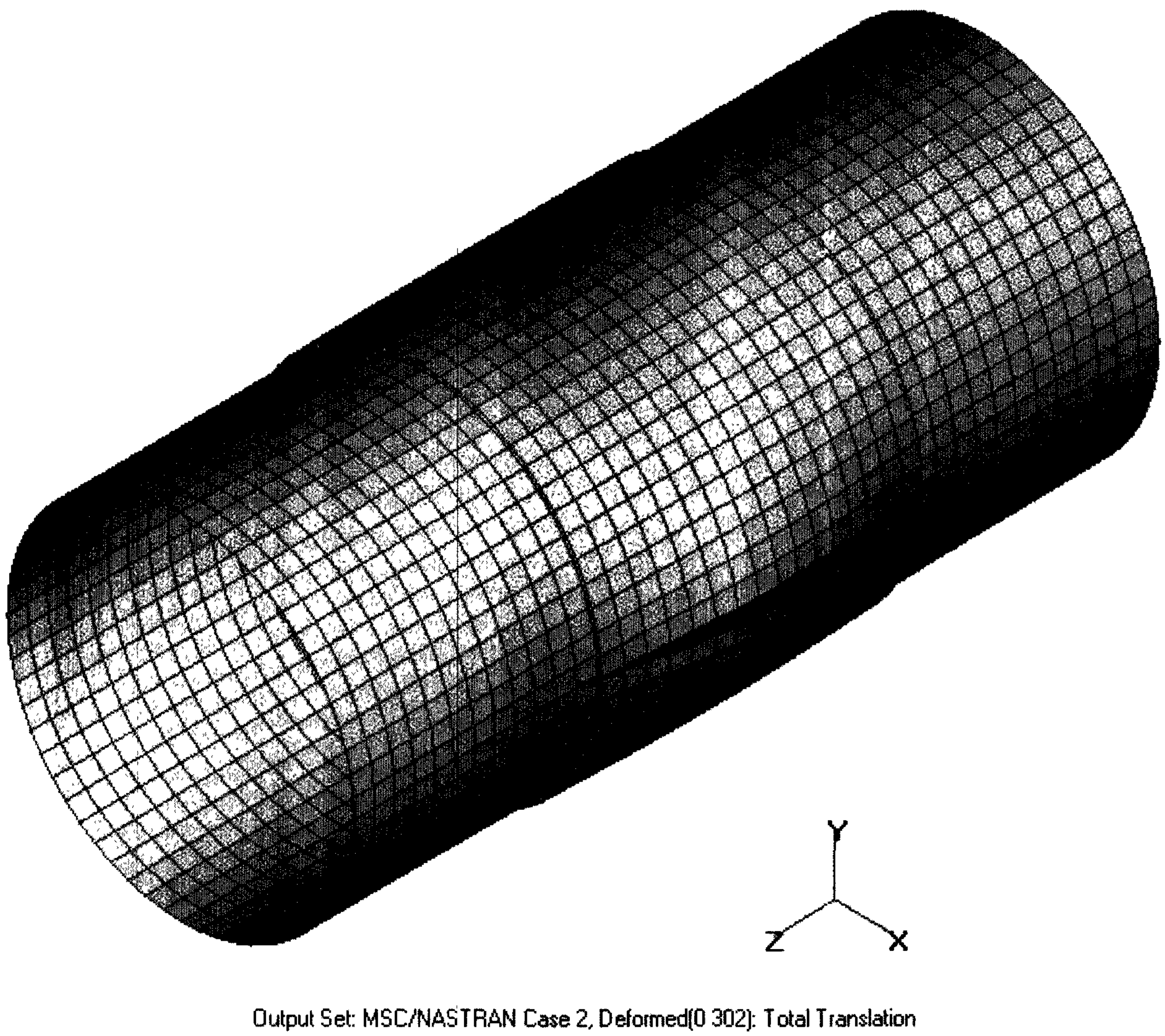

Figure 2 – Finite Element Mesh and Deformed Geometry of a Pipe with 8 ft Prestress Loss and Cracked Core Subjected to Internal Pressure, Pipe Weight, Fluid Weight, and Earth Load

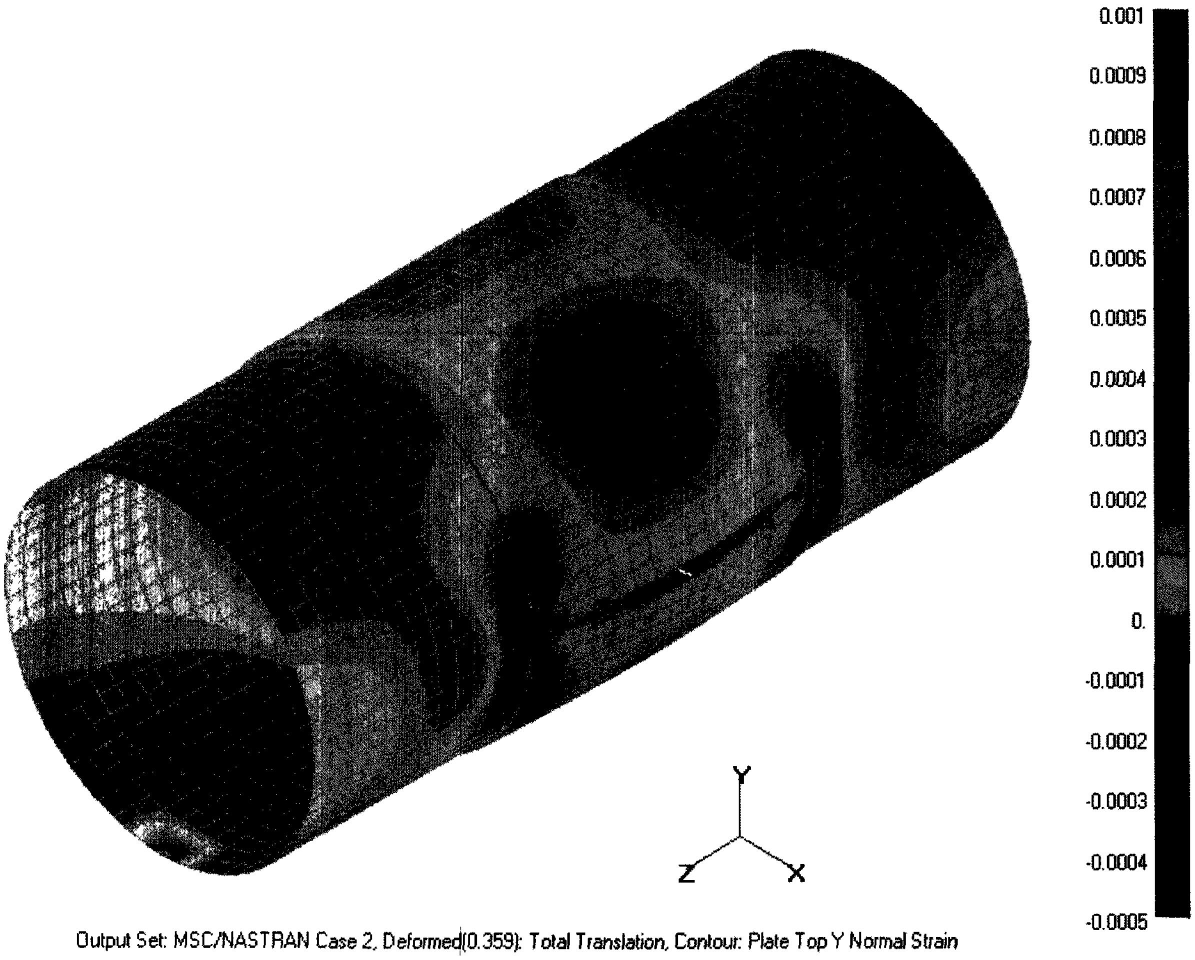

Figure 3 – Circumferential Strain for a Pipe with 8 ft Prestress Loss and Cracked Core Subjected to Internal Pressure, Pipe Weight, Fluid Weight, and Earth Loads

Pipe_Design = "84-01"

inside diameter	$D_i = 84in$	cylinder outside diameter	$D_y = 88.495in$
concrete core thickness	$h_c = 6.25in$	cylinder thickness	$t_y = 0.0598in$
prestressing steel area	$A_s = 0.526in^2 \cdot ft^{-1}$	prestress wire diameter	$d_s = 0.192in$
number of wires per foot	$n_w = 18.17ft^{-1}$	cylinder yield strength	$f_{yy} = 33000psi$
concrete strength	$f_c = 6100psi$	cylinder ultimate strength	$f_{yu} = 45000psi$
prestress pressure	$P_o = 137psi$	height of cover	$H = 12ft$
prestress in the core	$f_{cr} = 879psi$	earth load	$W_e = 15793lbf \cdot ft^{-1}$

pressure for ult. strength of cylinder $P_{yu} = 60.9psi$

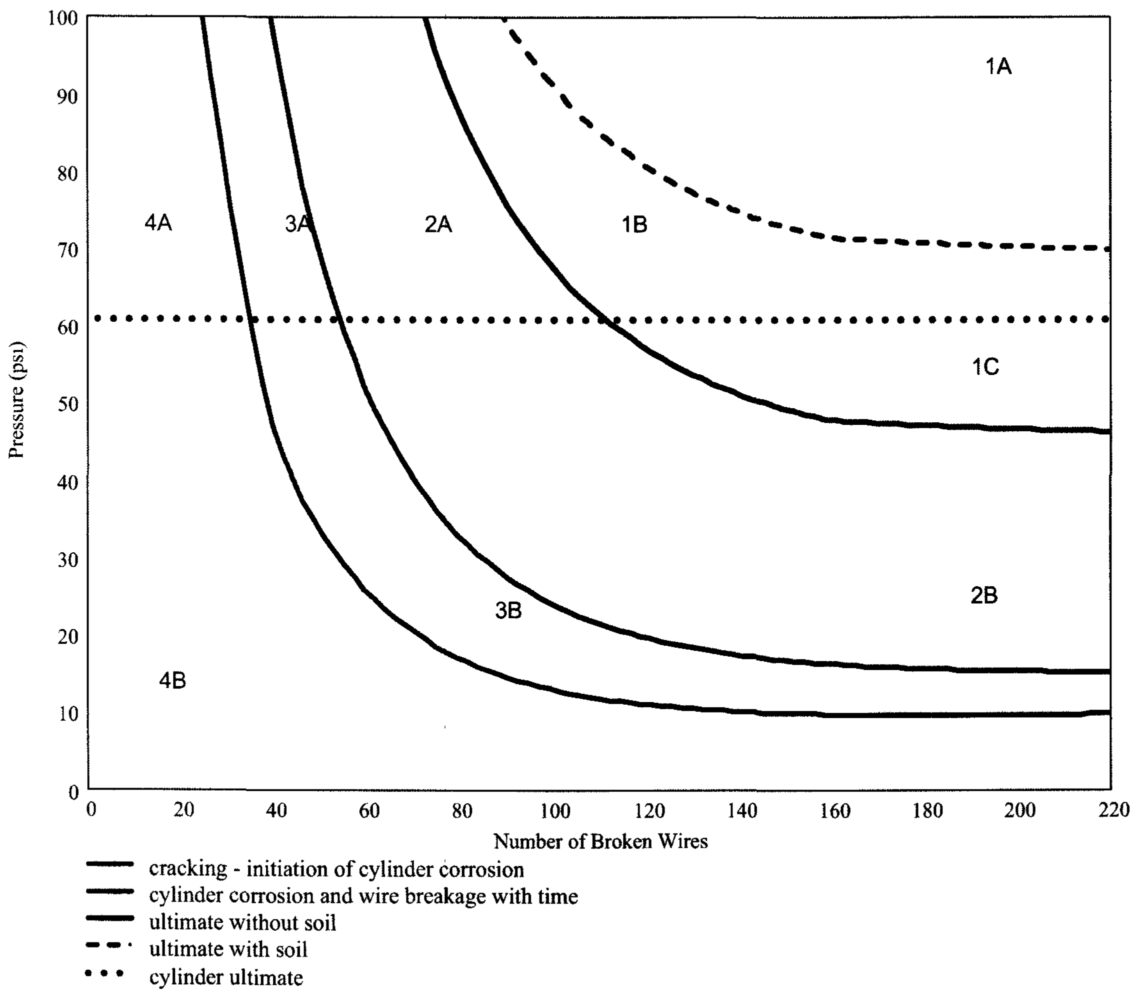

Figure 4 – Risk of Rupture and Repair Priorities for 84 in. Diameter Pipe Design 1 (Segment A-84-1: P_w = 32 psi, P_{max} = 48 psi, and Segment B-84-1: P_w = 36 psi, P_{max} = 54 psi, 12 ft of Soil Cover)

SIMPSON GUMPERTZ & HEGER INC.
BOSTON / SAN FRANCISCO / WASHINGTON, DC

SHEET NO ____ I____
COMM NO ____
CLIENT Intermountain Power Service Corporation, Delta, UT
DATE 02 December 2003
SUBJECT Risk of Failure for Pipe with Broken Prestressing Wires
BY RPO
CHECK BY MSZ

Pipe_Design = "84-02"

inside diameter	$D_i = 84in$	cylinder outside diameter	$D_y = 88.495in$
concrete core thickness	$h_c = 6.25in$	cylinder thickness	$t_y = 0.0598in$
prestressing steel area	$A_s = 0.428in^2 \cdot ft^{-1}$	prestress wire diameter	$d_s = 0.192in$
number of wires per foot	$n_w = 14.78ft^{-1}$	cylinder yield strength	$f_{yy} = 33000psi$
concrete strength	$f_c = 5100psi$	cylinder ultimate strength	$f_{yu} = 45000psi$
prestress pressure	$P_o = 110psi$	height of cover	$H = 7ft$
prestress in the core	$f_{cr} = 708psi$	earth load	$W_e = 8136lbf \cdot ft^{-1}$

pressure for ult. strength of cylinder $P_{yu} = 60.9psi$

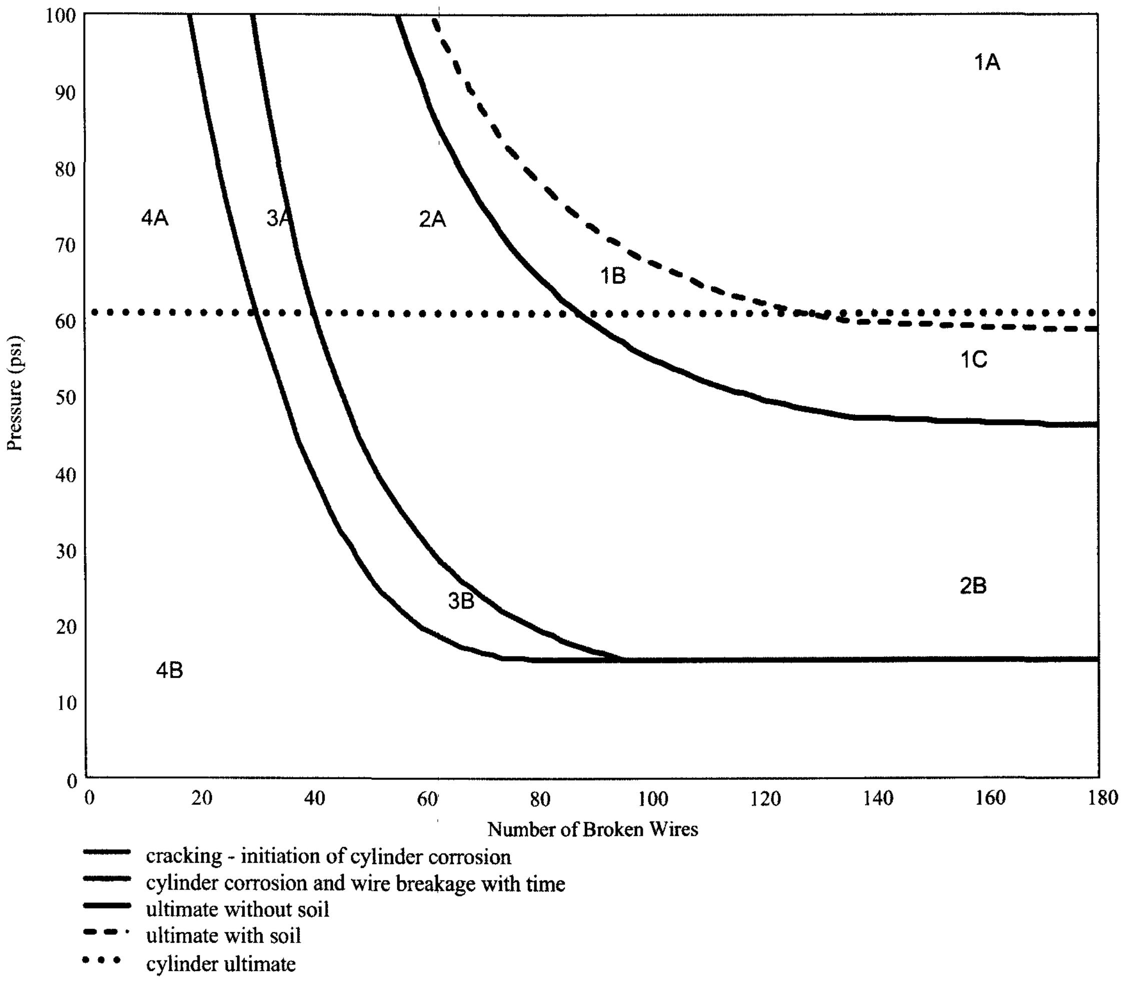

Figure 5 – Risk of Rupture and Repair Priorities for 84-in. Diameter Pipe Design 2 (Segments A-84-2 and A-84-3: P_w = 27 psi, P_{max} = 41 psi, 7 ft of Soil Cover)

Pipe_Design = "84-02-ga12"

inside diameter	$D_i = 84in$	cylinder outside diameter	$D_y = 88.584in$
concrete core thickness	$h_c = 6.25in$	cylinder thickness	$t_y = 0.1046in$
prestressing steel area	$A_s = 0.428in^2 \cdot ft^{-1}$	prestress wire diameter	$d_s = 0.192in$
number of wires per foot	$n_w = 14.78ft^{-1}$	cylinder yield strength	$f_{yy} = 33000psi$
concrete strength	$f_c = 5100psi$	cylinder ultimate strength	$f_{yu} = 45000psi$
prestress pressure	$P_o = 100psi$	height of cover	$H = 7ft$
prestress in the core	$f_{cr} = 614psi$	earth load	$W_e = 8136lbf \cdot ft^{-1}$
pressure for ult. strength of cylinder	$P_{yu} = 106.4psi$		

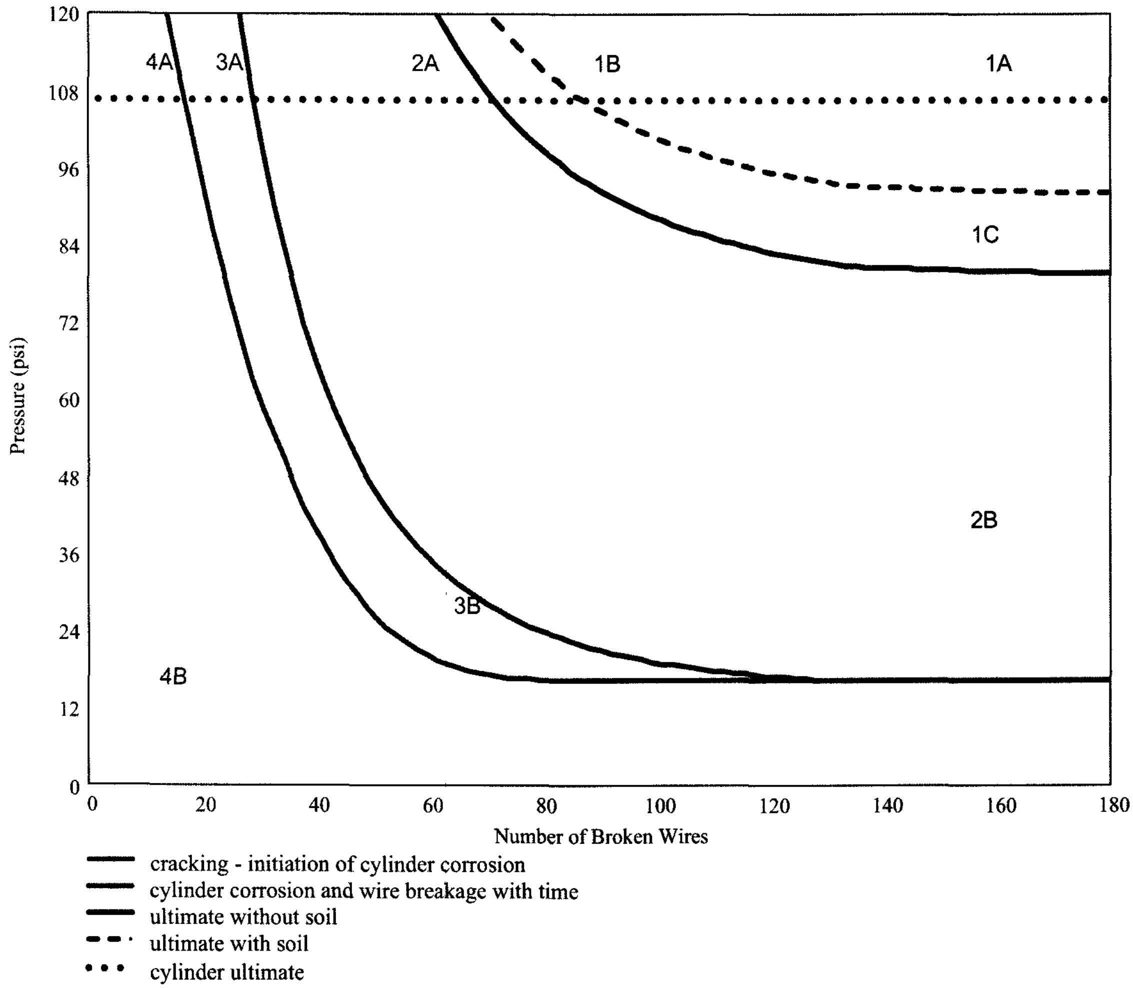

Figure 6 – Risk of Rupture and Repair Priorities for 84 in. Diameter Pipe Design 2 with gage 12 steel cylinder
(Segments A-84-2 and A-84-3: P_w = 27 psi, P_{max} = 41 psi, 7 ft of Soil Cover)

SIMPSON GUMPERTZ & HEGER INC.
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SHEET NO ______ I____
COMM. NO ______
CLIENT Intermountain Power Service Corporation, Delta, UT
DATE 02 December 2003
SUBJECT Risk of Failure for Pipe with Broken Prestressing Wires
BY RPO
CHECK BY MSZ

Pipe_Design = "114-01"

inside diameter	$D_i = 114in$	cylinder outside diameter	$D_y = 118.495in$
concrete core thickness	$h_c = 8.75in$	cylinder thickness	$t_y = 0.0598in$
prestressing steel area	$A_s = 0.793in^2 \cdot ft^{-1}$	prestress wire diameter	$d_s = 0.192in$
number of wires per foot	$n_w = 27.39ft^{-1}$	cylinder yield strength	$f_{yy} = 33000psi$
concrete strength	$f_c = 6300psi$	cylinder ultimate strength	$f_{yu} = 45000psi$
prestress pressure	$P_o = 163psi$	height of cover	$H = 10.5ft$
prestress in the core	$f_{cr} = 1011psi$	earth load	$W_e = 16857lbf \cdot ft^{-1}$

pressure for ult. strength of cylinder $P_{yu} = 45.4psi$

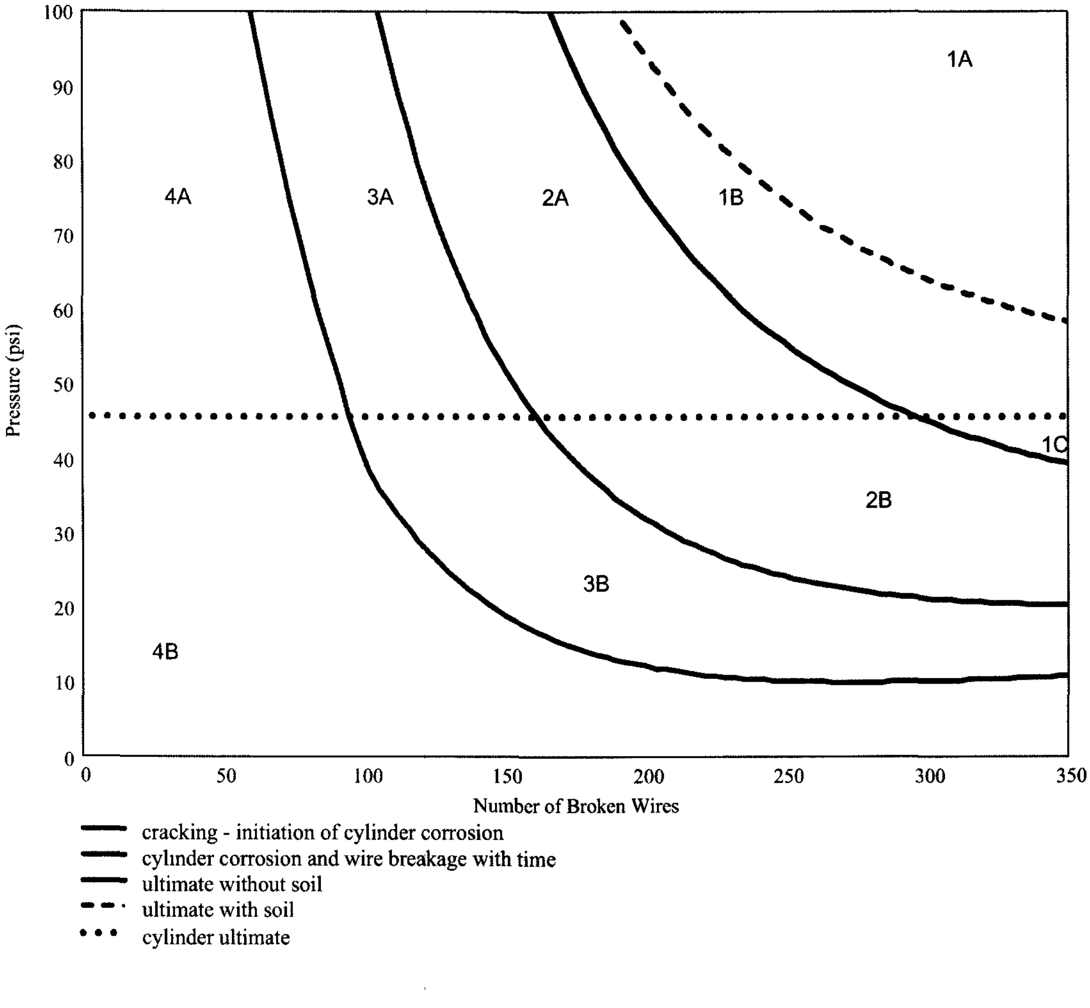

Figure 7 – Risk of Rupture and Repair Priorities for 114 in. Diameter Pipe Design (Segment A-114: P_w = 32 psi, P_{max} = 48 psi, and Segment B-114: P_w = 36 psi, P_{max} = 54 psi, 10.5 ft of Soil Cover)

IP12_003789

Pipe_Design = "120-01-5ft"

inside diameter	$D_i = 120\text{in}$	cylinder outside diameter	$D_y = 124.495\text{in}$
concrete core thickness	$h_c = 9.25\text{in}$	cylinder thickness	$t_y = 0.0598\text{in}$
prestressing steel area	$A_s = 0.646\text{in}^2 \cdot \text{ft}^{-1}$	prestress wire diameter	$d_s = 0.192\text{in}$
number of wires per foot	$n_w = 22.31\text{ft}^{-1}$	cylinder yield strength	$f_{yy} = 33000\text{psi}$
concrete strength	$f_c = 5800\text{psi}$	cylinder ultimate strength	$f_{yu} = 45000\text{psi}$
prestress pressure	$P_o = 127\text{psi}$	height of cover	$H = 5\,\text{ft}$
prestress in the core	$f_{cr} = 791\text{psi}$	earth load	$W_e = 7622\text{lbf} \cdot \text{ft}^{-1}$

pressure for ult. strength of cylinder $P_{yu} = 43.3\text{psi}$

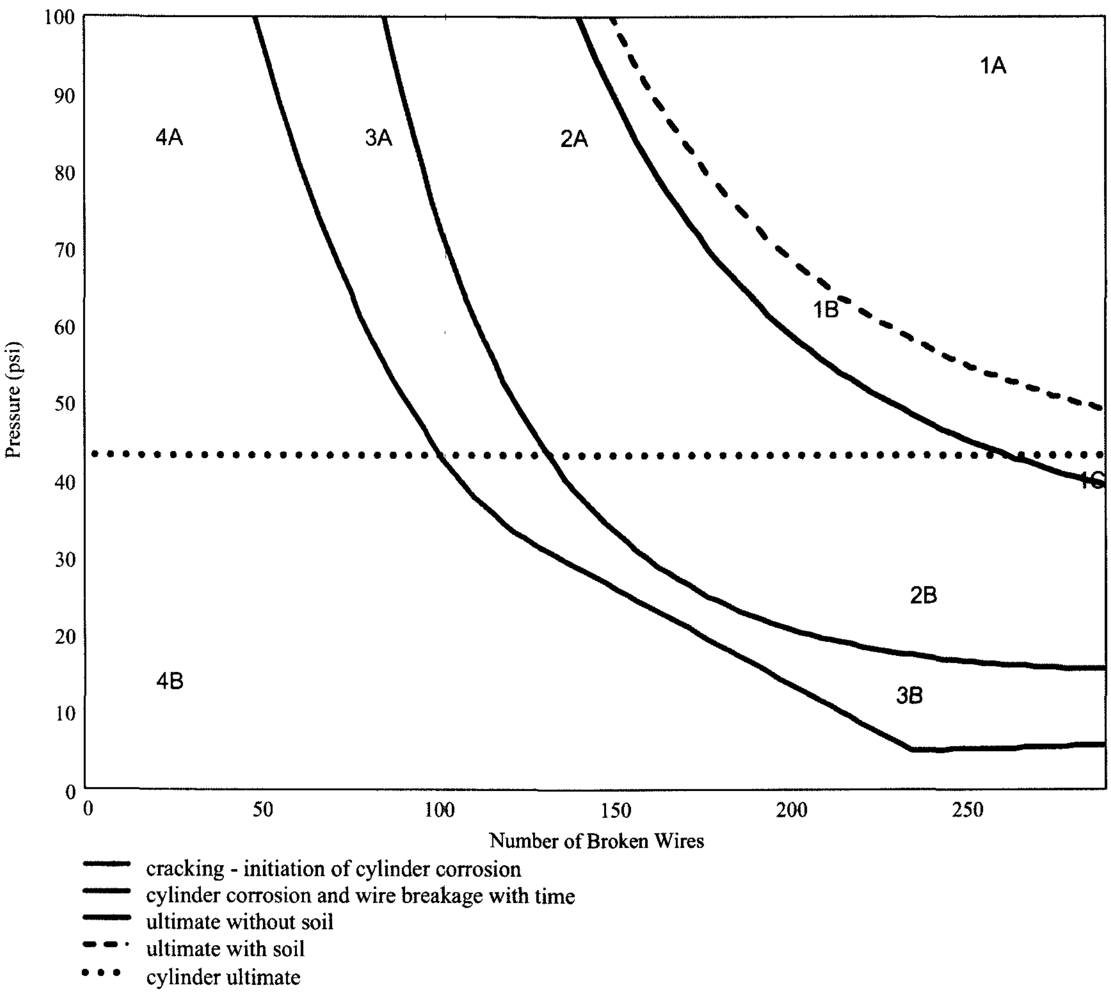

Figure 8 – Risk of Rupture and Repair Priorities for 120 in. Diameter Pipe Design (Segment A-120: P_w = 32 psi, P_{max} = 48 psi, 5 ft of Soil Cover)

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SHEET NO ______ 1 ______
COMM NO ______

CLIENT Intermountain Power Service Corporation, Delta, UT
SUBJECT Risk of Failure for Pipe with Broken Prestressing Wires

DATE 02 December 2003
BY RPO
CHECK BY MSZ

Pipe_Design = "120-01-10ft"

inside diameter	$D_i = 120in$	cylinder outside diameter	$D_y = 124.495in$
concrete core thickness	$h_c = 9.25in$	cylinder thickness	$t_y = 0.0598in$
prestressing steel area	$A_s = 0.646in^2 \cdot ft^{-1}$	prestress wire diameter	$d_s = 0.192in$
number of wires per foot	$n_w = 22.31ft^{-1}$	cylinder yield strength	$f_{yy} = 33000psi$
concrete strength	$f_c = 5800psi$	cylinder ultimate strength	$f_{yu} = 45000psi$
prestress pressure	$P_o = 127psi$	height of cover	$H = 10ft$
prestress in the core	$f_{cr} = 791psi$	earth load	$W_e = 16587lbf \cdot ft^{-1}$

pressure for ult. strength of cylinder $P_{yu} = 43.3psi$

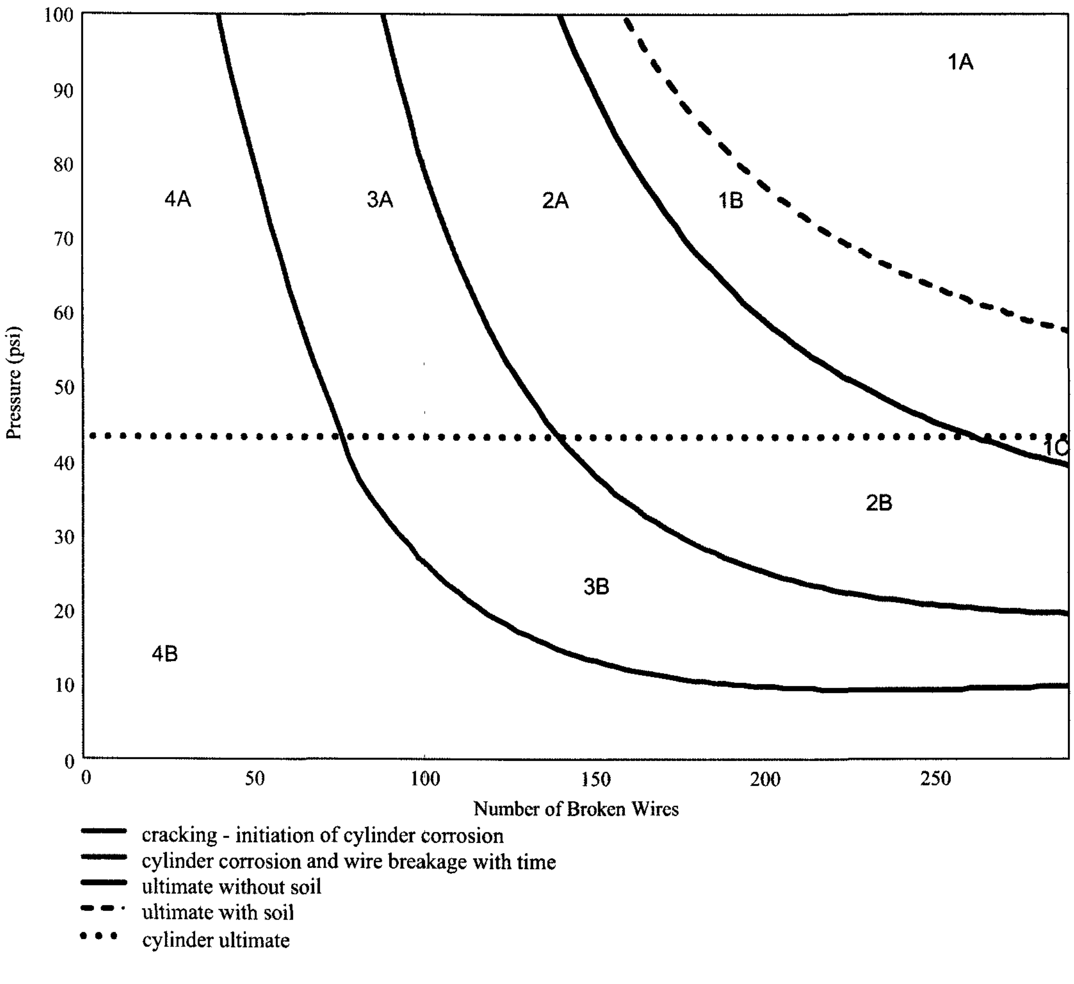

Figure 9 – Risk of Rupture and Repair Priorities for 120 in. Diameter Pipe Design (Segment A-120: P_w = 32 psi, P_{max} = 48 psi, and Segment B-120: P_w = 36 psi, P_{max} = 54 psi, 10 ft of Soil Cover)

Pipe_Design = "120-FW"

inside diameter	$D_i = 120in$	cylinder outside diameter	$D_y = 124.584in$
concrete core thickness	$h_c = 9.25in$	cylinder thickness	$t_y = 0.1046in$
prestressing steel area	$A_s = 0.646in^2 \cdot ft^{-1}$	prestress wire diameter	$d_s = 0.192in$
number of wires per foot	$n_w = 22.31ft^{-1}$	cylinder yield strength	$f_{yy} = 33000psi$
concrete strength	$f_c = 5800psi$	cylinder ultimate strength	$f_{yu} = 45000psi$
prestress pressure	$P_o = 120psi$	height of cover	$H = 10ft$
prestress in the core	$f_{cr} = 725psi$	earth load	$W_e = 16587lbf \cdot ft^{-1}$

pressure for ult. strength of cylinder $P_{yu} = 75.6psi$

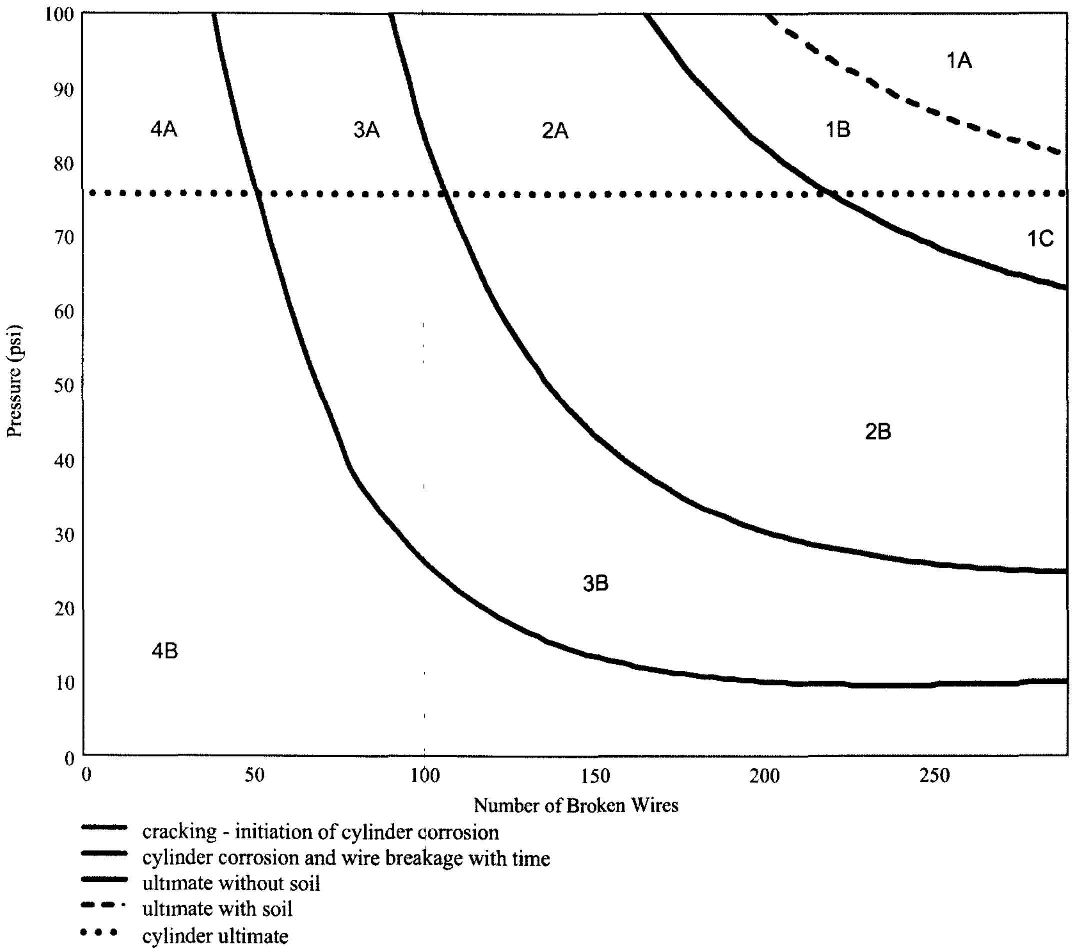

Figure 10 – Risk of Rupture and Repair Priorities for 120 in. Diameter Pipe Design (Segment A-120: P_w = 32 psi, P_{max} = 48 psi, and Segment B-120: P_w = 36 psi, P_{max} = 54 psi, 10 ft of Soil Cover, gage 12 Steel Cylinder)

Pipe_Design = "120-01-20ft"

inside diameter	$D_i = 120in$	cylinder outside diameter	$D_y = 124.495in$
concrete core thickness	$h_c = 9.25in$	cylinder thickness	$t_y = 0.0598in$
prestressing steel area	$A_s = 0.646in^2 \cdot ft^{-1}$	prestress wire diameter	$d_s = 0.192in$
number of wires per foot	$n_w = 22.31ft^{-1}$	cylinder yield strength	$f_{yy} = 33000psi$
concrete strength	$f_c = 5800psi$	cylinder ultimate strength	$f_{yu} = 45000psi$
prestress pressure	$P_o = 127psi$	height of cover	$H = 20ft$
prestress in the core	$f_{cr} = 791psi$	earth load	$W_e = 39540lbf \cdot ft^{-1}$
pressure for ult. strength of cylinder	$P_{yu} = 43.3psi$		

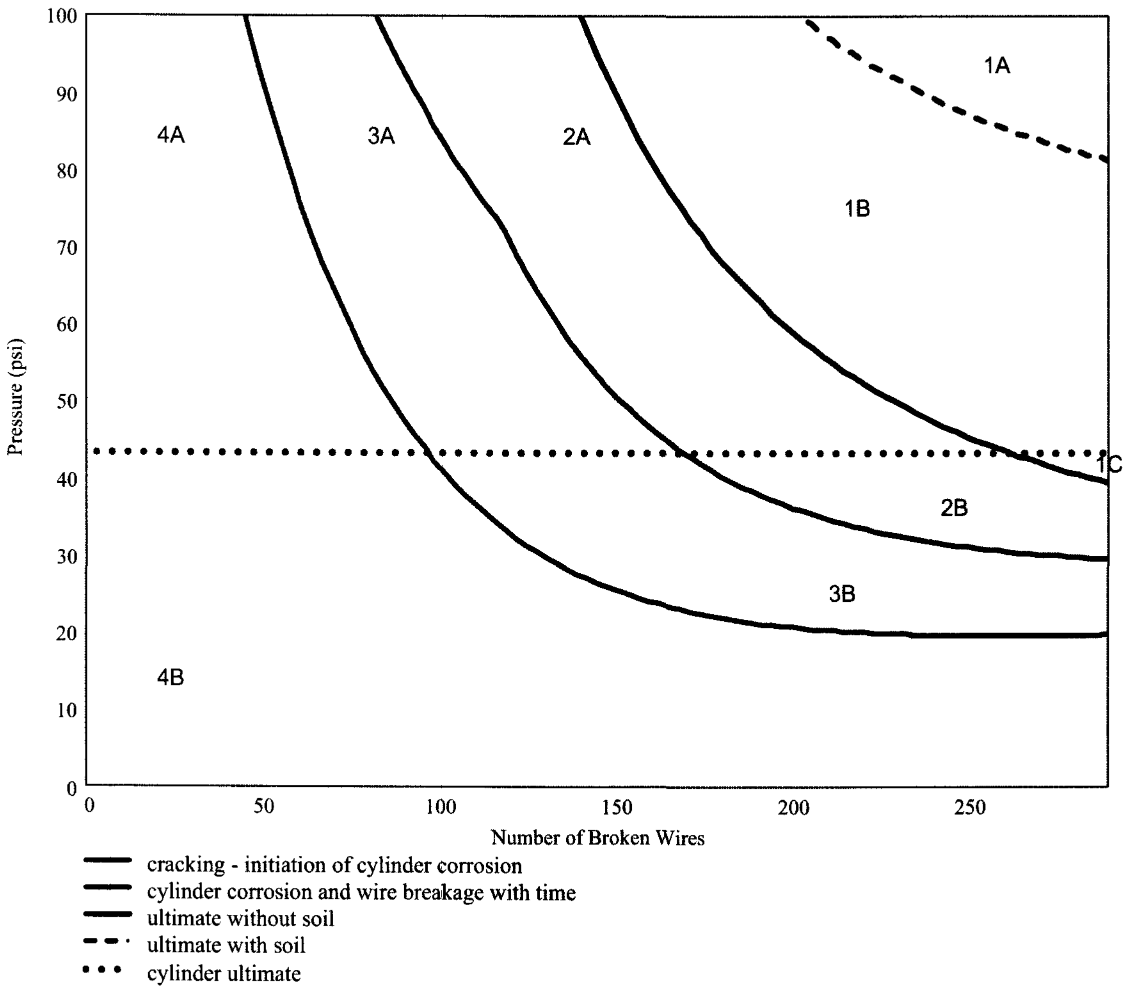

Figure 11 – Risk of Rupture and Repair Priorities for 120 in. Diameter Pipe Design (Segment A-120: P_w = 32 psi, P_{max} = 48 psi, and Segment B-120: P_w = 36 psi, P_{max} = 54 psi, 20 ft of Soil Cover)

Pipe_Design = "144-01"

inside diameter	$D_i = 144\text{in}$	cylinder outside diameter	$D_y = 149.745\text{in}$
concrete core thickness	$h_c = 12\text{in}$	cylinder thickness	$t_y = 0.0598\text{in}$
prestressing steel area	$A_s = 0.319\text{in}^2 \cdot \text{ft}^{-1}$	prestress wire diameter	$d_s = 0.192\text{in}$
number of wires per foot	$n_w = 11.02\text{ft}^{-1}$	cylinder yield strength	$f_{yy} = 33000\text{psi}$
concrete strength	$f_c = 4500\text{psi}$	cylinder ultimate strength	$f_{yu} = 45000\text{psi}$
prestress pressure	$P_o = 53\text{psi}$	height of cover	$H = 3\text{ft}$
prestress in the core	$f_{cr} = 313\text{psi}$	earth load	$W_e = 5308\text{lbf} \cdot \text{ft}^{-1}$

pressure for ult. strength of cylinder $P_{yu} = 36\text{psi}$

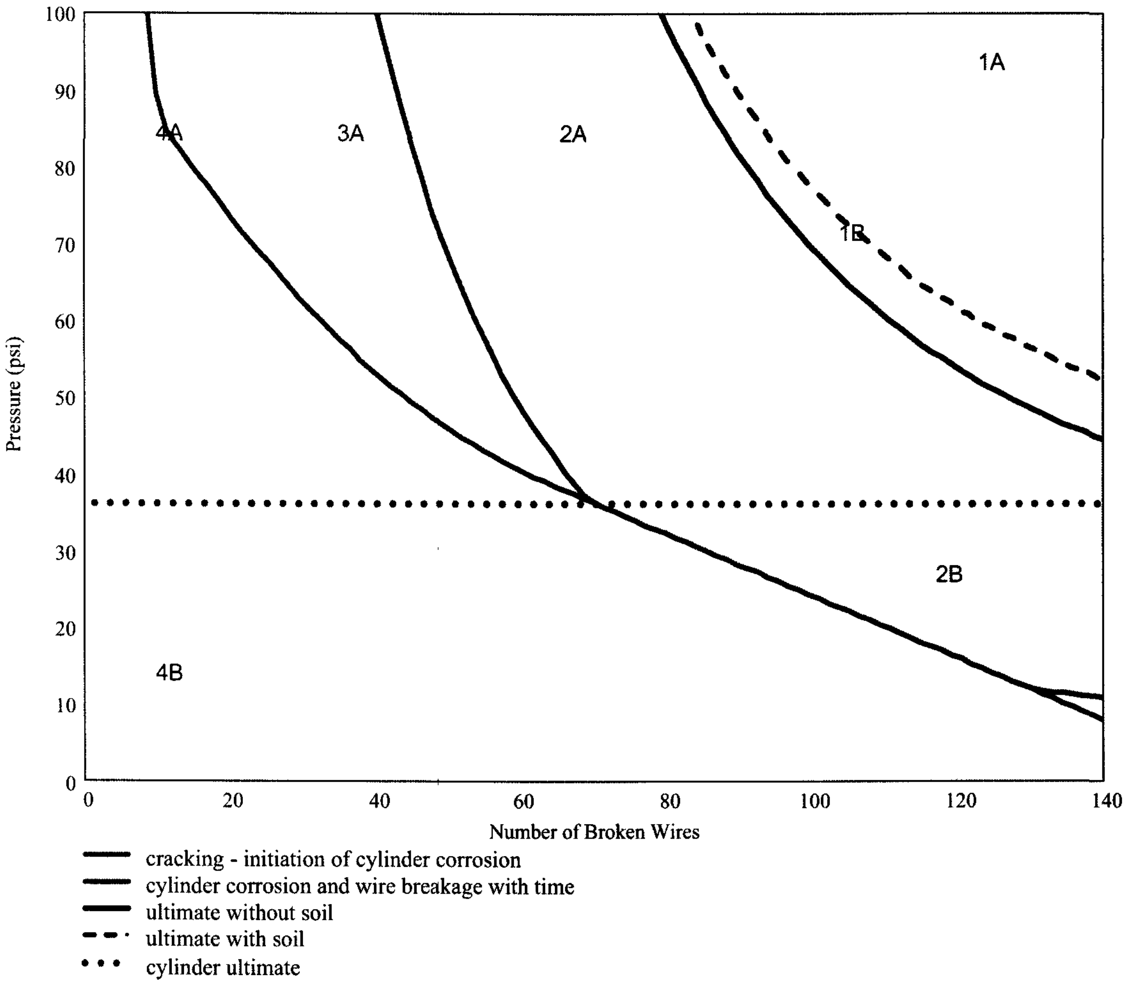

Figure 12 – Risk of Rupture and Repair Priorities for 144 in. Diameter Pipe Design (Segments C-144 and D-144: P_w = 12 psi, P_{max} = 18 psi, 3 ft of Soil Cover)

Pipe_Design = "84-02"

inside diameter	$D_i = 84\text{in}$	cylinder outside diameter	$D_y = 88.495\text{in}$
concrete core thickness	$h_c = 6.25\text{in}$	cylinder thickness	$t_y = 0.0598\text{in}$
prestressing steel area	$A_s = 0.428\text{in}^2 \cdot \text{ft}^{-1}$	prestress wire diameter	$d_s = 0.192\text{in}$
number of wires per foot	$n_w = 14.78\text{ft}^{-1}$	cylinder yield strength	$f_{yy} = 33000\text{psi}$
concrete strength	$f_c = 5100\text{psi}$	cylinder ultimate strength	$f_{yu} = 45000\text{psi}$
prestress pressure	$P_o = 110\text{psi}$	height of cover	$H = 7\,\text{ft}$
prestress in the core	$f_{cr} = 708\text{psi}$	earth load	$W_e = 8136\text{lbf} \cdot \text{ft}^{-1}$

pressure for ult. strength of cylinder $P_{yu} = 60.9\text{psi}$

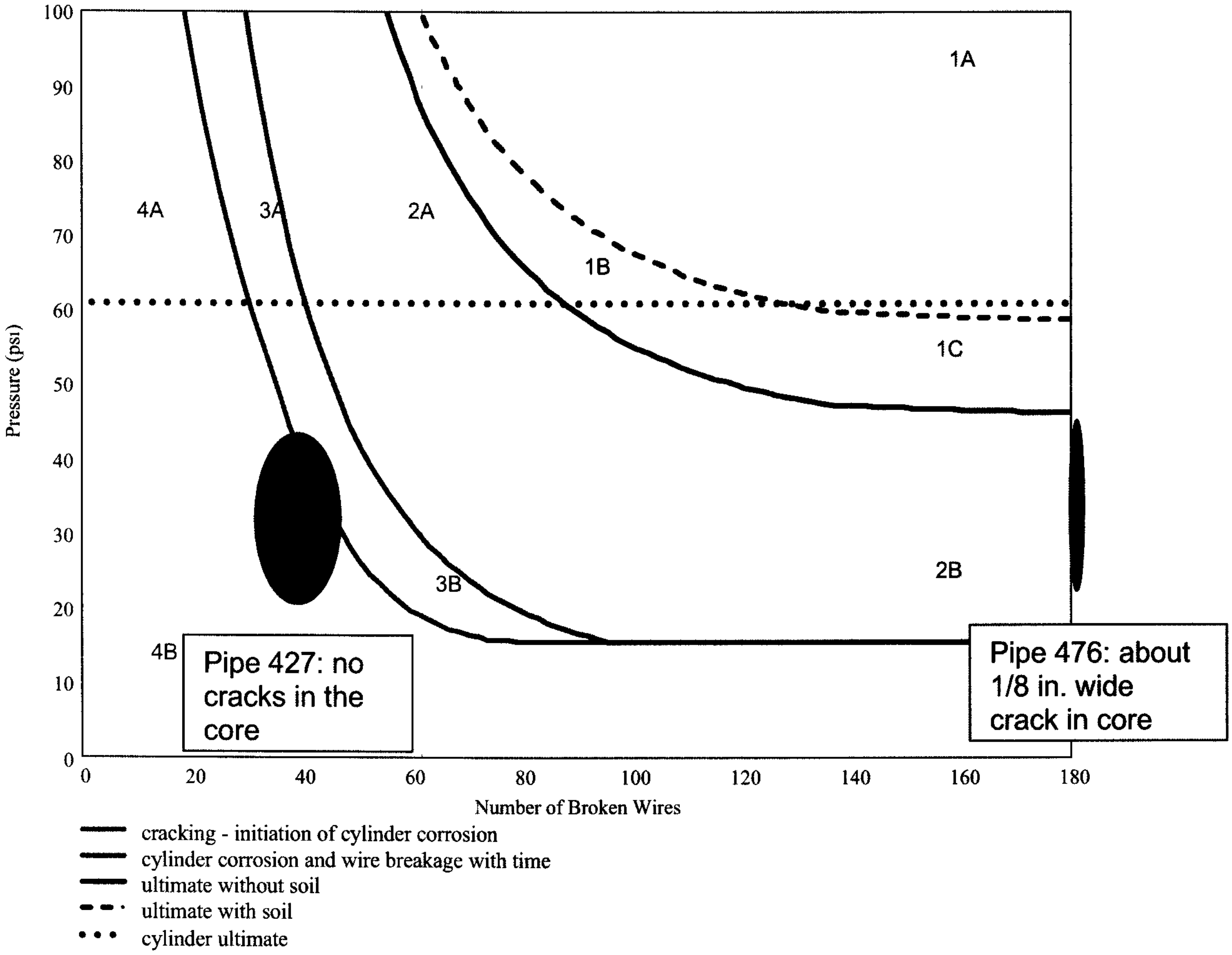

Figure 13 – Comparison of Field Inspection Results and Risk of Rupture and Repair Priorities for 84 in. Diameter Pipe Design

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BOSTON / SAN FRANCISCO / WASHINGTON, DC	COMM NO
CLIENT Intermountain Power Service Corporation, Delta, UT	DATE 02 December 2003
SUBJECT Risk of Failure for Pipe with Broken Prestressing Wires	BY RPO
	CHECK BY MSZ

Pipe_Design = "120-01-5ft"

inside diameter	$D_i = 120\text{in}$	cylinder outside diameter	$D_y = 124.495\text{in}$
concrete core thickness	$h_c = 9.25\text{in}$	cylinder thickness	$t_y = 0.0598\text{in}$
prestressing steel area	$A_s = 0.646\text{in}^2 \cdot \text{ft}^{-1}$	prestress wire diameter	$d_s = 0.192\text{in}$
number of wires per foot	$n_w = 22.31\text{ft}^{-1}$	cylinder yield strength	$f_{yy} = 33000\text{psi}$
concrete strength	$f_c = 5800\text{psi}$	cylinder ultimate strength	$f_{yu} = 45000\text{psi}$
prestress pressure	$P_o = 127\text{psi}$	height of cover	$H = 5\text{ft}$
prestress in the core	$f_{cr} = 791\text{psi}$	earth load	$W_e = 7622\text{lbf} \cdot \text{ft}^{-1}$

pressure for ult. strength of cylinder $P_{yu} = 43.3\text{psi}$

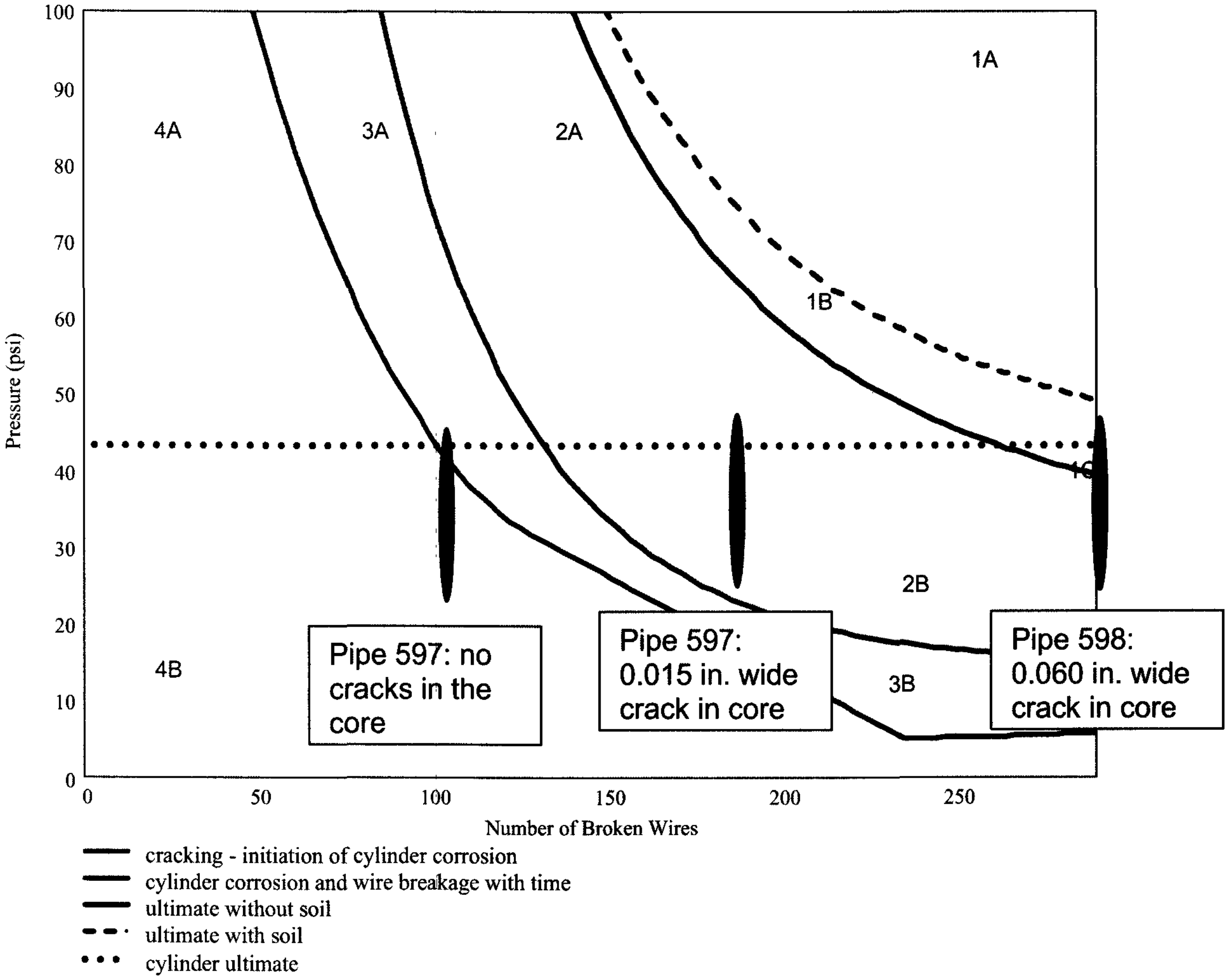

Figure 14 – Comparison of Field Inspection Results and Risk of Rupture and Repair Priorities for 120 in. Diameter Pipe Design

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[1] Bold capitalized headings are tab indexed.

Photo 1

84 in. diameter pipes removed from the line that was inspected in the yard.

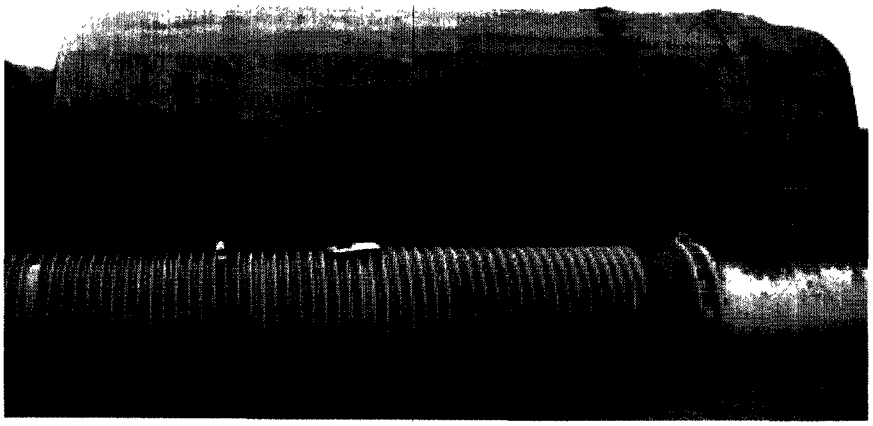


Photo 2

84 in. diameter Pipe #427. Note six areas with hollow sounding and/or cracked coating.

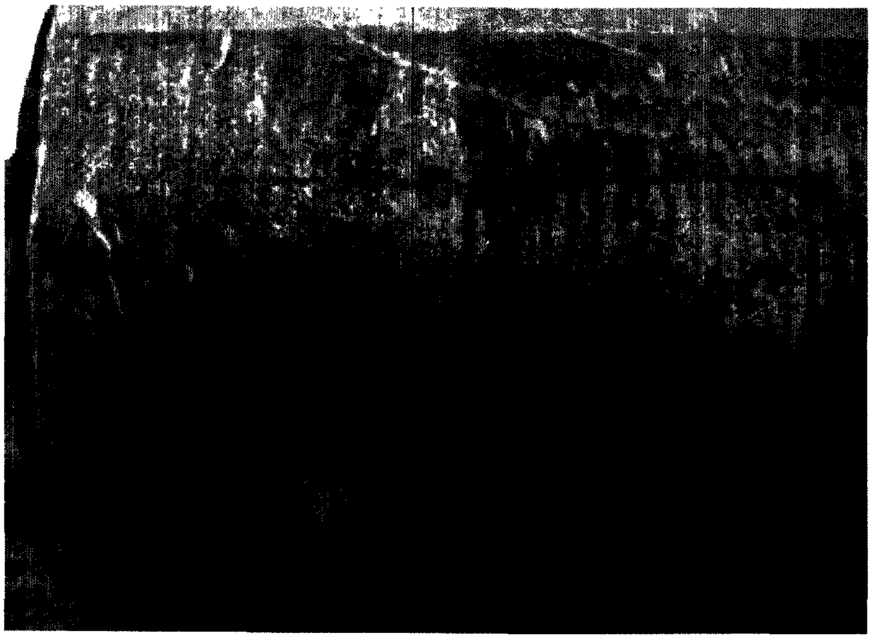


Photo 3

84 in. diameter Pipe #427. Close-up of the Photo Number 2.

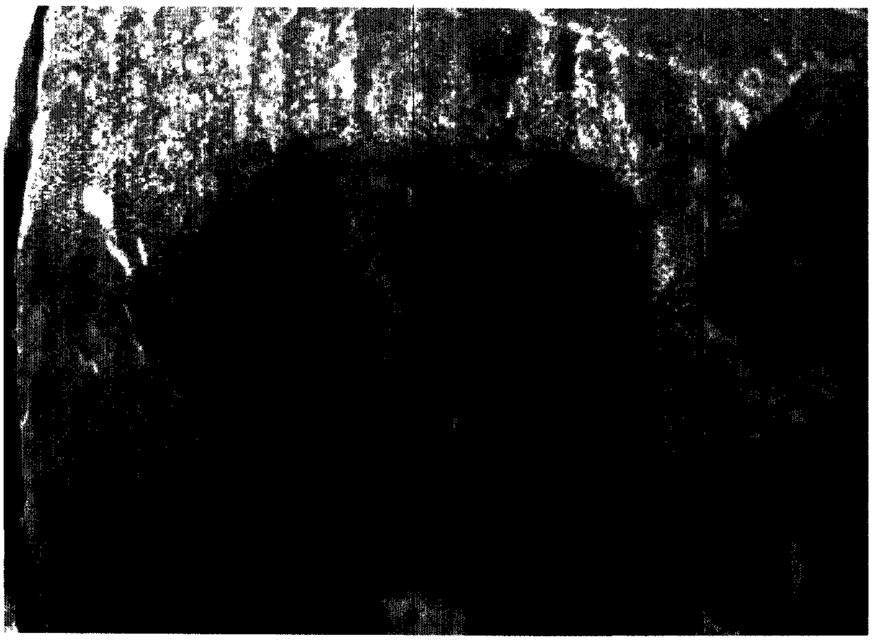


Photo 4

84 in. diameter Pipe #427. Corroded and broken wires under the hollow-sounding coating. Note that area of corroded wire is smaller than the area of hollow-sounding coating.

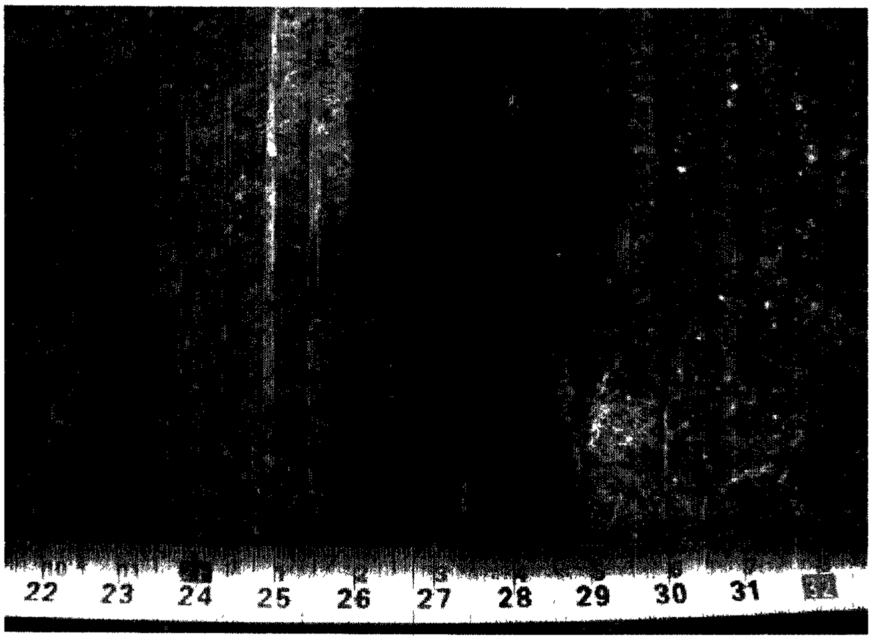


Photo 5

84 in. diameter Pipe #427. Close-up of corroded and broken wires shown in Photo 4.

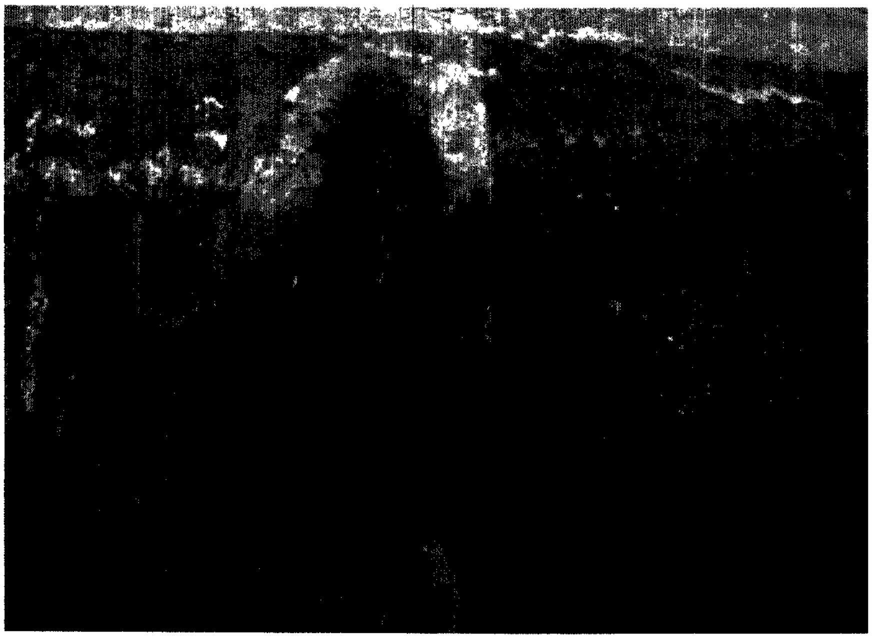


Photo 6

84 in. diameter Pipe #427. Close-up of corroded and broken wires.

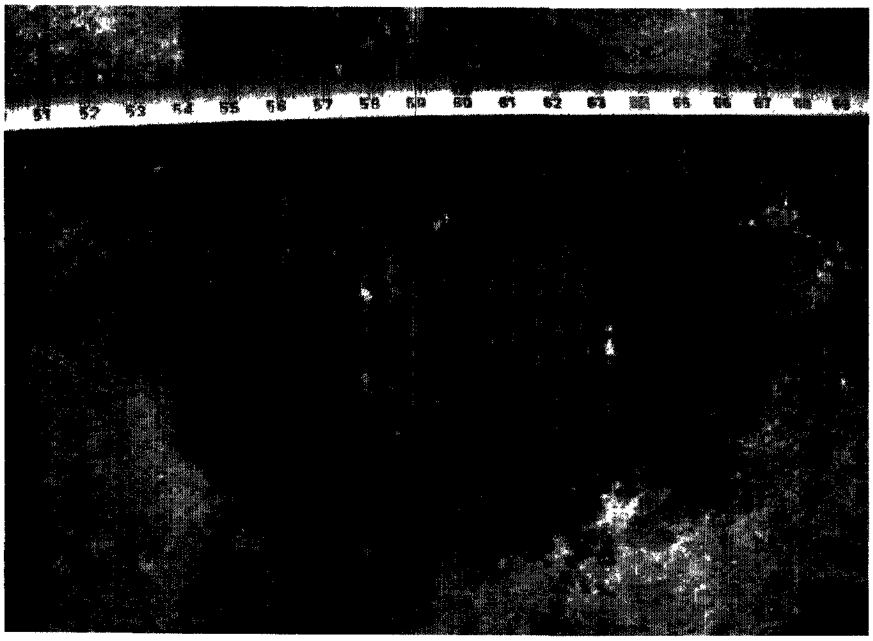


Photo 7

84 in. diameter Pipe #427. Close-up of corroded and broken wires.

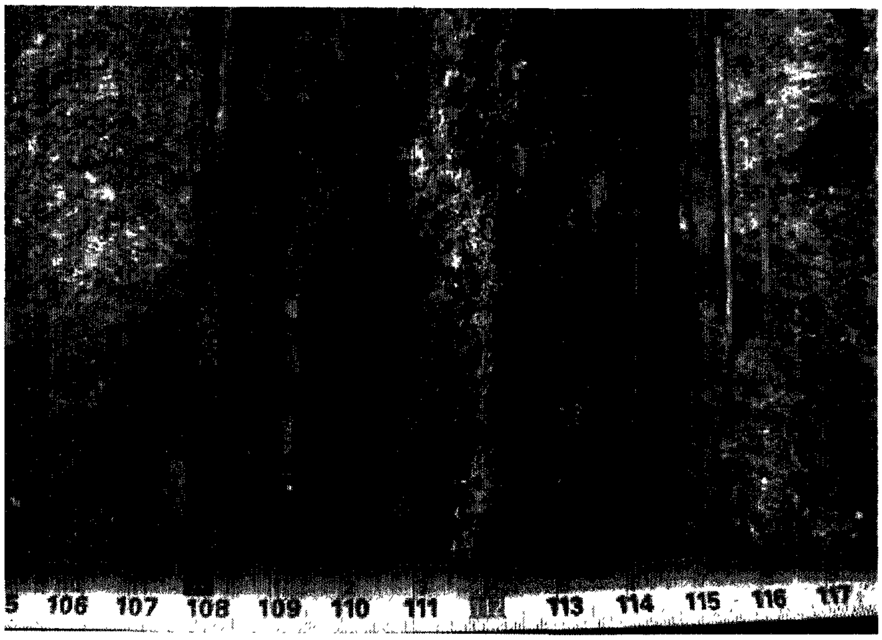


Photo 8

84 in. diameter Pipe #427. Close-up of corroded and broken wires.

Photo 9

84 in. diameter Pipe #427. Close-up of corroded and broken wires.

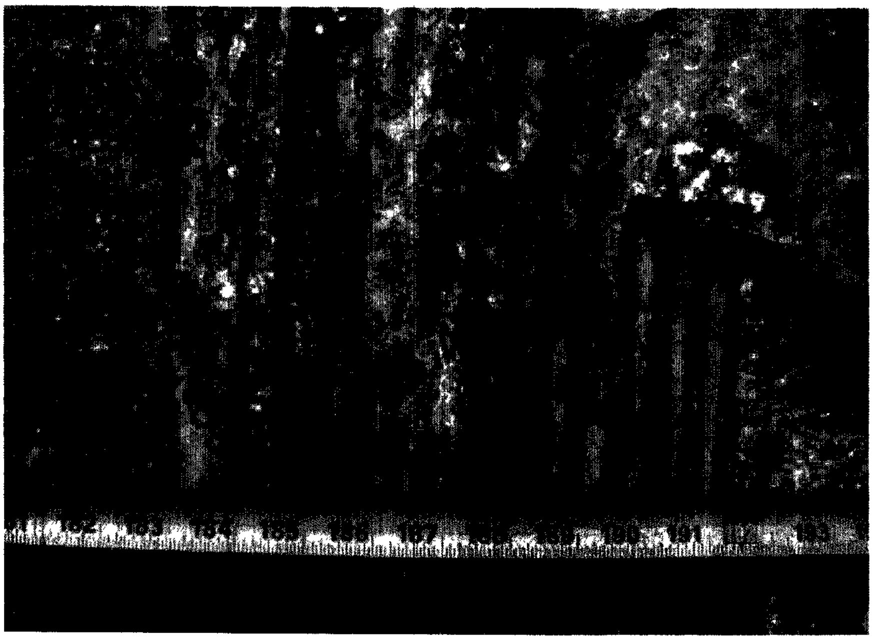


Photo 10

84 in. diameter Pipe #427. Note circumferential crack in the core about 0.005 to 0.007 in. wide. The crack is located near the 45° elbow on the outer side of the elbow.

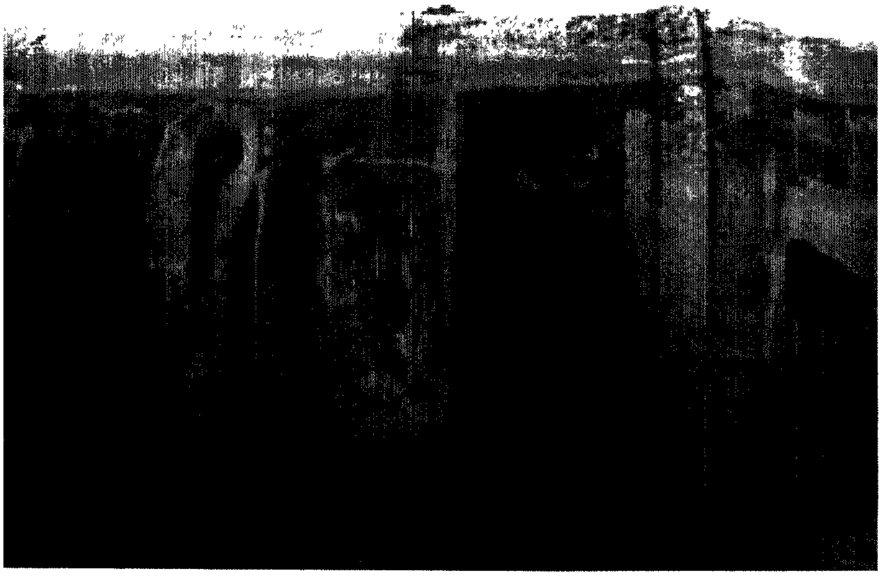


Photo 11

84 in. diameter Pipe #427. Window opened in core to expose the steel cylinder.

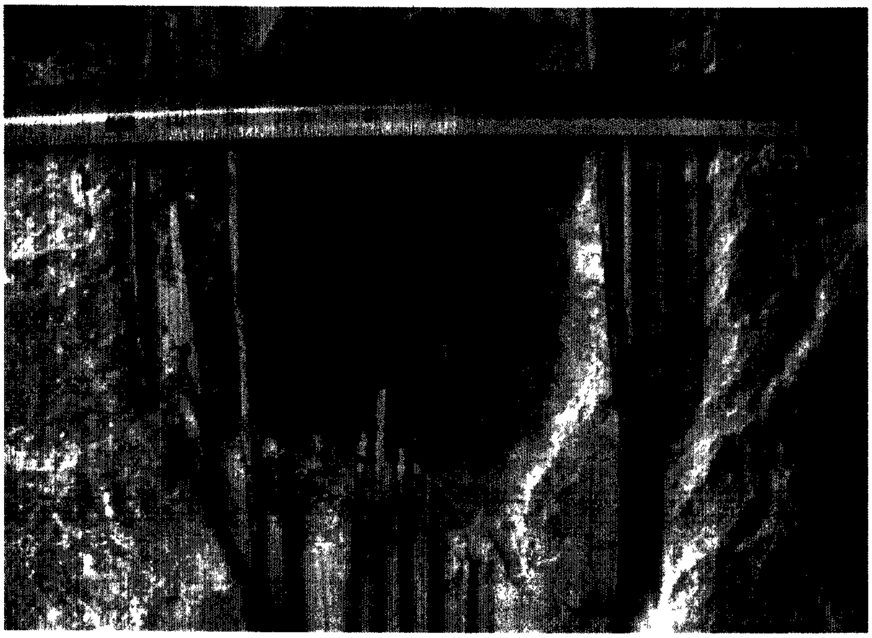


Photo 12

84 in. diameter Pipe #427. Clean steel cylinder under the 0.005 to 0.007 in. wide circumferential core crack.

Photo 13

84 in. diameter Pipe #476. Spalled coating over most of the pipe length.

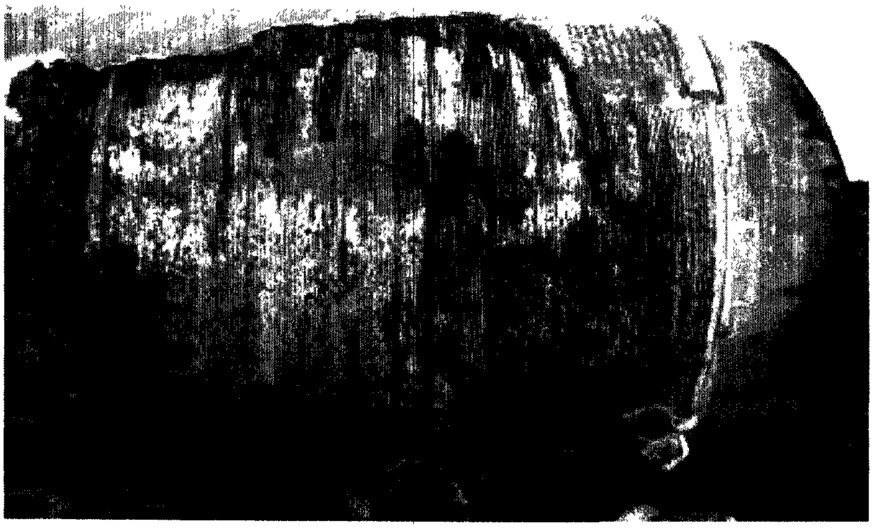


Photo 14

84 in. diameter Pipe #476. Note longitudinal crack in concrete core.

Photo 15

84 in. diameter Pipe #476. Up to about 1/8 in. wide longitudinal crack in the core.

Photo 16

84 in. diameter Pipe #476. Spalled coating near the other end of the pipe.

Photo 17

84 in. diameter Pipe #476. Window opened in core to expose the steel cylinder.

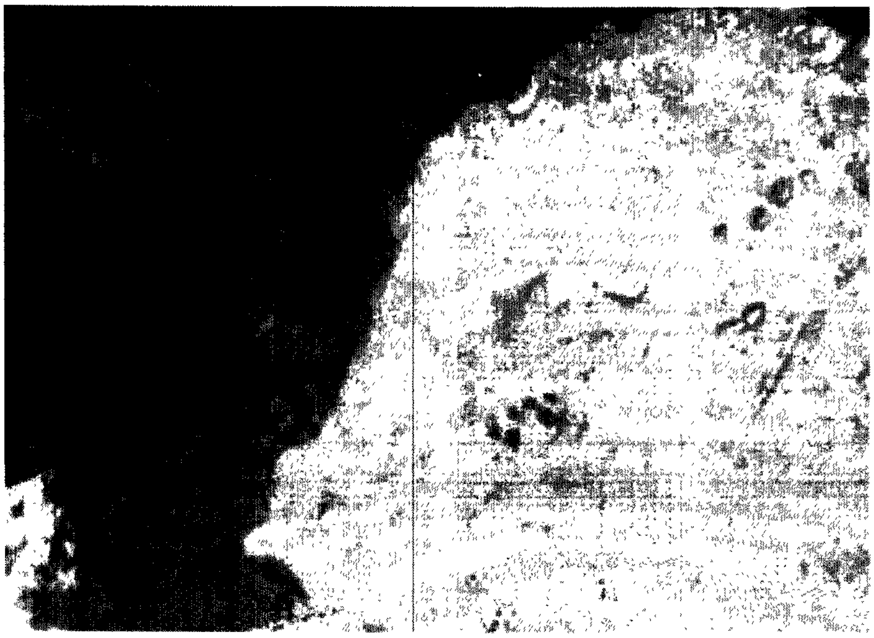


Photo 18

84 in. diameter Pipe #476. Steel cylinder with only minor surface rust under an 1/8 in. wide longitudinal crack.

Photo 19

120 in. diameter Pipe #597, northeast side. Note two BWZ identified by RFEC/TC.

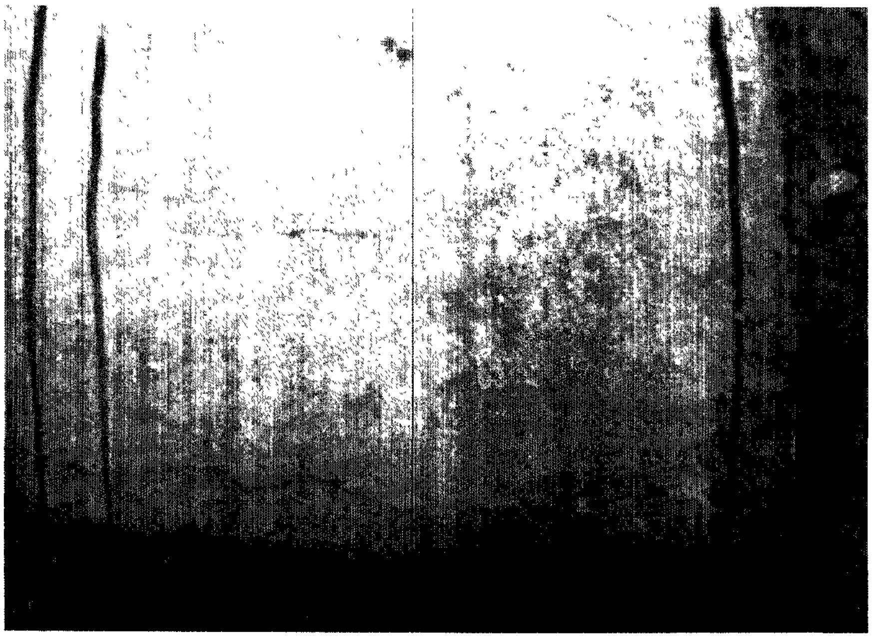


Photo 20

120 in. diameter Pipe #597, northeast side. Coating cracks in BWZ.

Photo 21

120 in. diameter Pipe #597, northeast side. Up to about 0.040 in. wide coating crack and hollow-sounding coating.

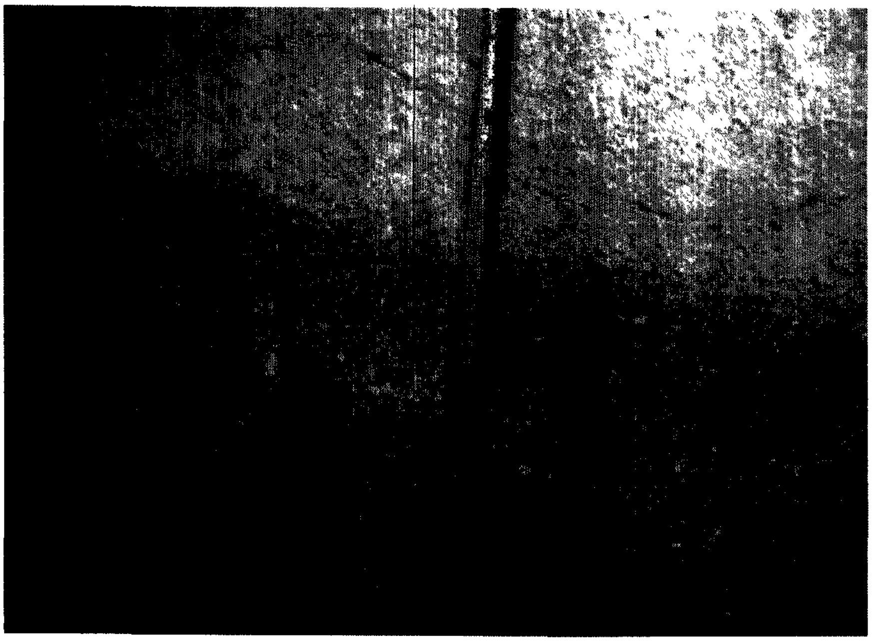


Photo 22

120 in. diameter Pipe #597, northeast side. Coating cracks spaced at about 6 in. to 12 in.

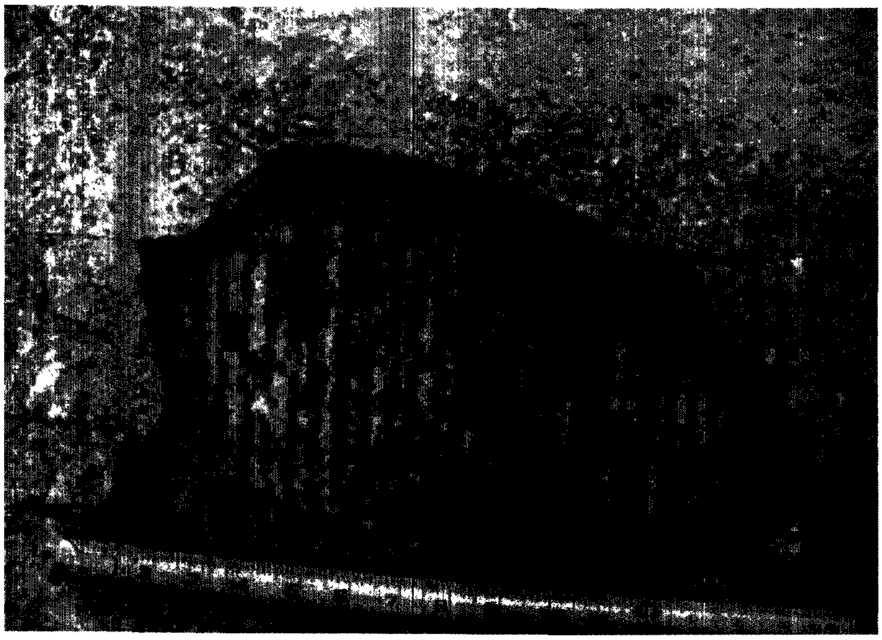


Photo 23

120 in. diameter Pipe #597, northeast side. Disintegrated wires under hollow-sounding coating in BWZ.

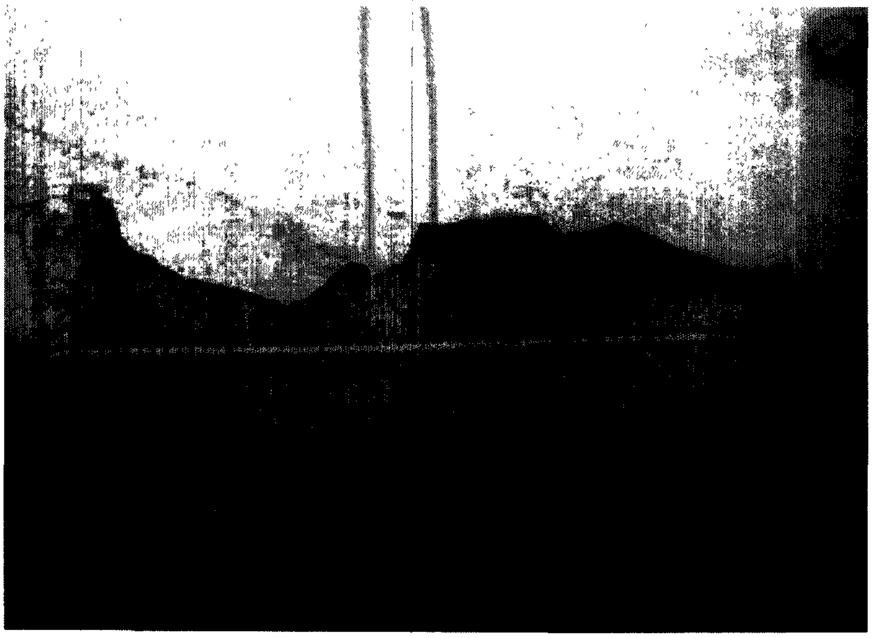


Photo 24

120 in. diameter Pipe #597, northeast side. Disintegrated wires in both BWZ and between two BWZ.

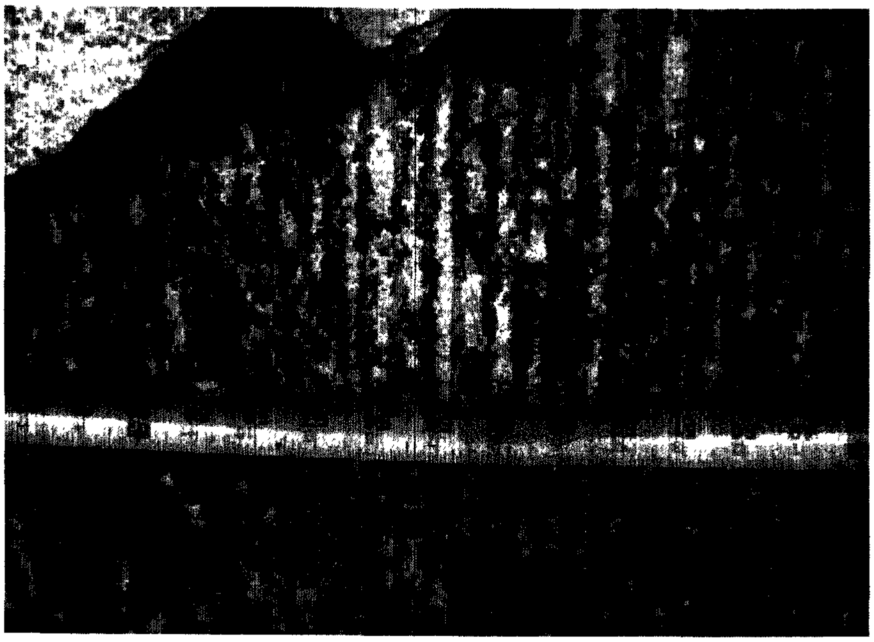


Photo 25

120 in. diameter Pipe #597, northeast side. Core crack near springline about 0.015 in. wide.

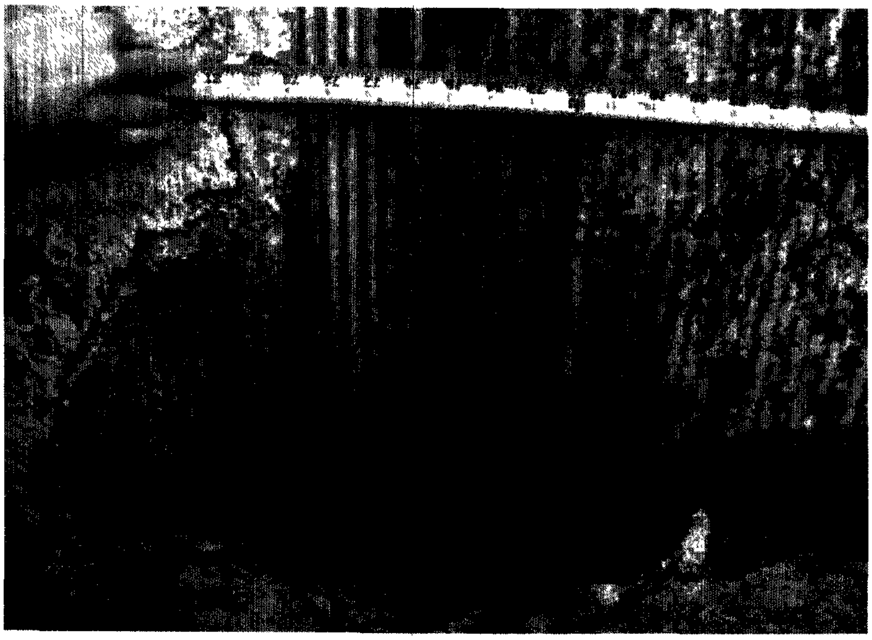


Photo 26

120 in. diameter Pipe #597, northeast side. End of broken wires near springline. Note that corroded wires extend down toward invert (not excavated).

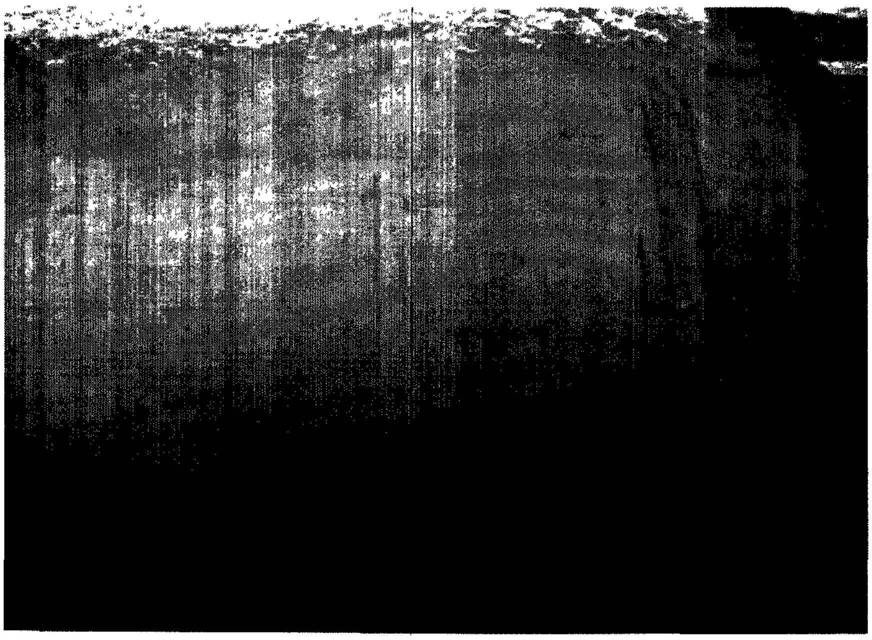


Photo 27

120 in. diameter Pipe #597, northeast side. Extent of corroded and broken wires near the springline. Note that corroded and likely broken wires extend down below the springline within the BWZ on the left.

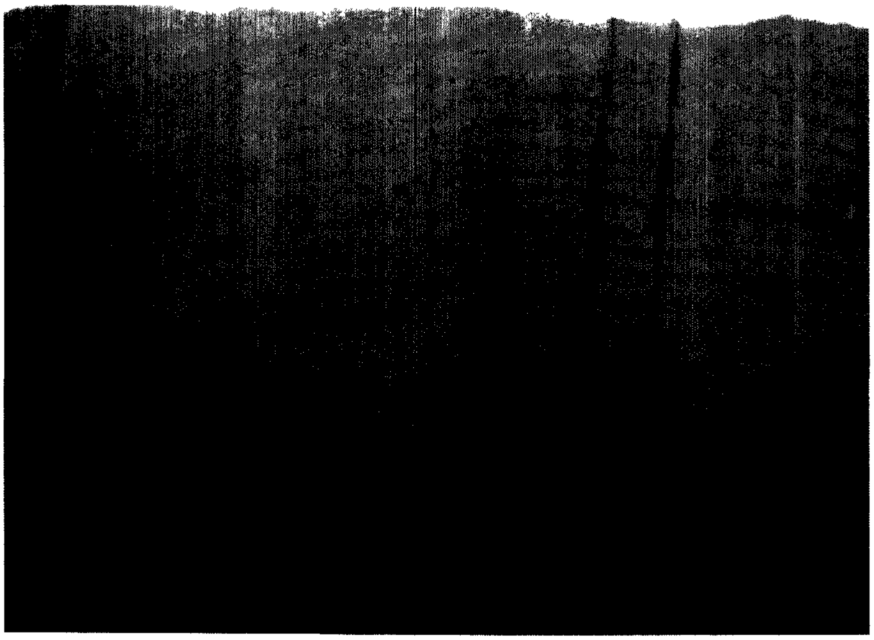


Photo 28

120 in. diameter Pipe #597, southwest side. BWZ on the other side of the pipe.

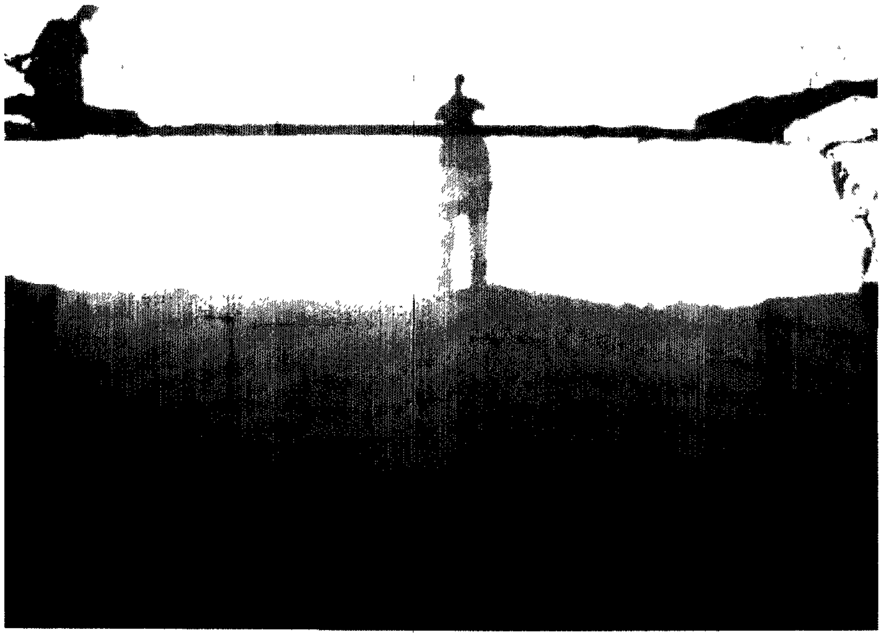


Photo 29

120 in. diameter Pipe #597, southwest side. Corroded and broken wires in BWZ.

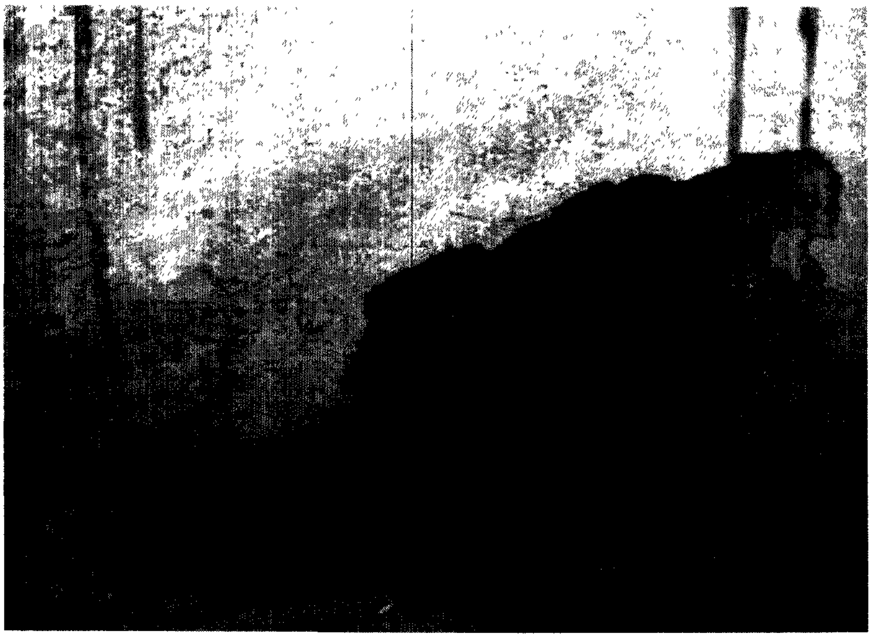


Photo 30

120 in. diameter Pipe #597, southwest side. End of corroded and broken wires at the end of BWZ.

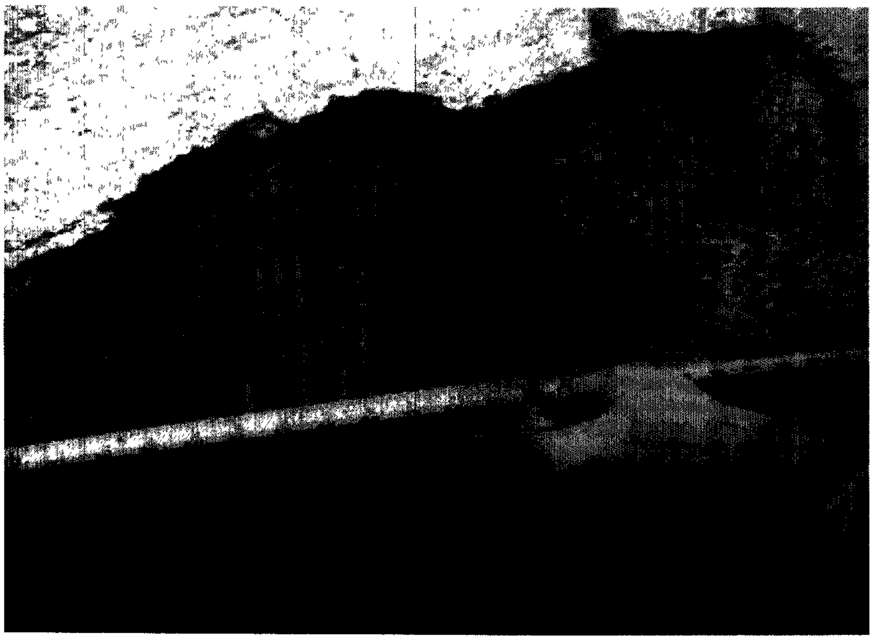


Photo 31

120 in. diameter Pipe #597, southwest side. Close-up of Photo 30.

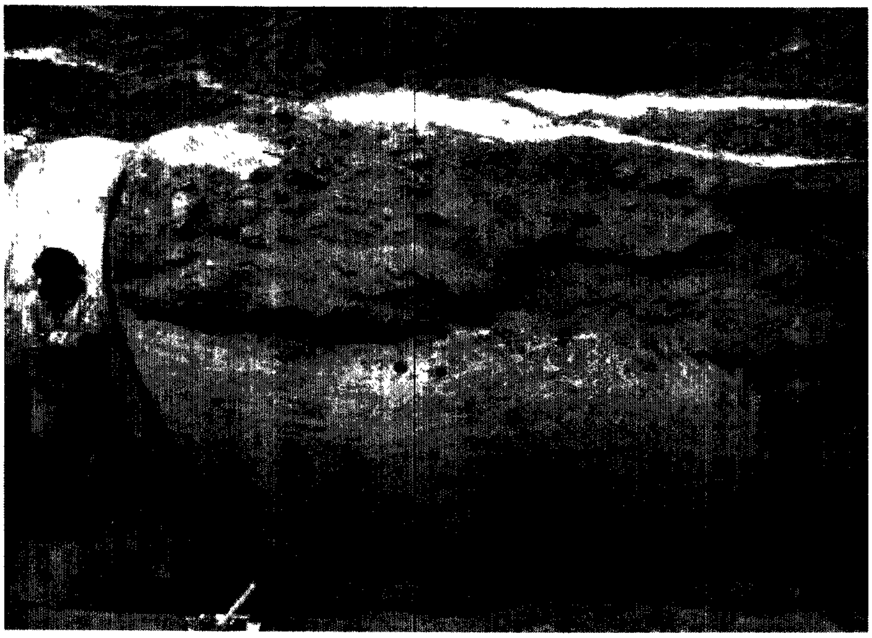


Photo 32

120 in. diameter Pipe #598, southwest side. Cracks in the coating and hollow-sounding coating along pipe length.

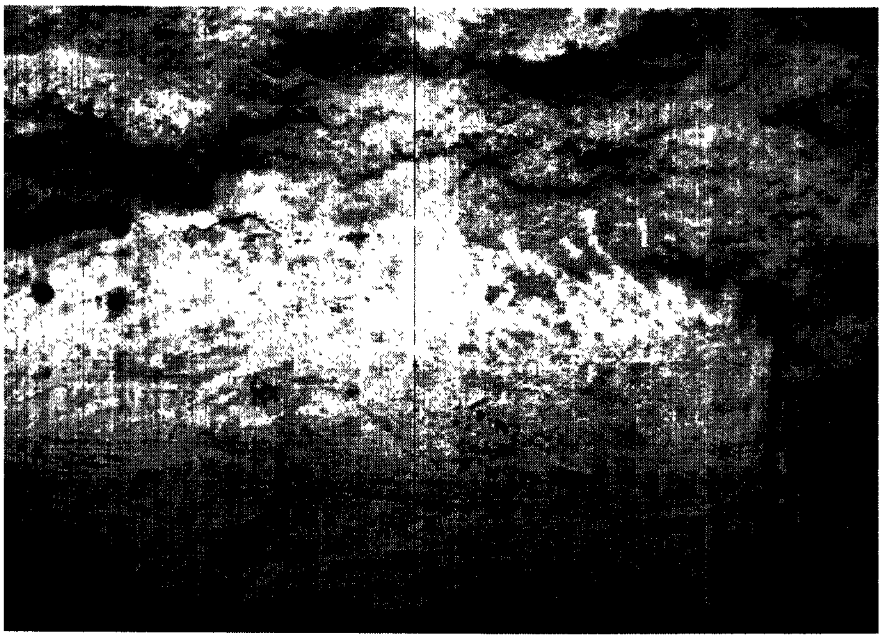


Photo 33

120 in. diameter Pipe #598, southwest side. Close-up of Photo 32.

Photo 34

120 in. diameter Pipe #598, southwest side. Disintegrated wires under hollow-sounding coating.

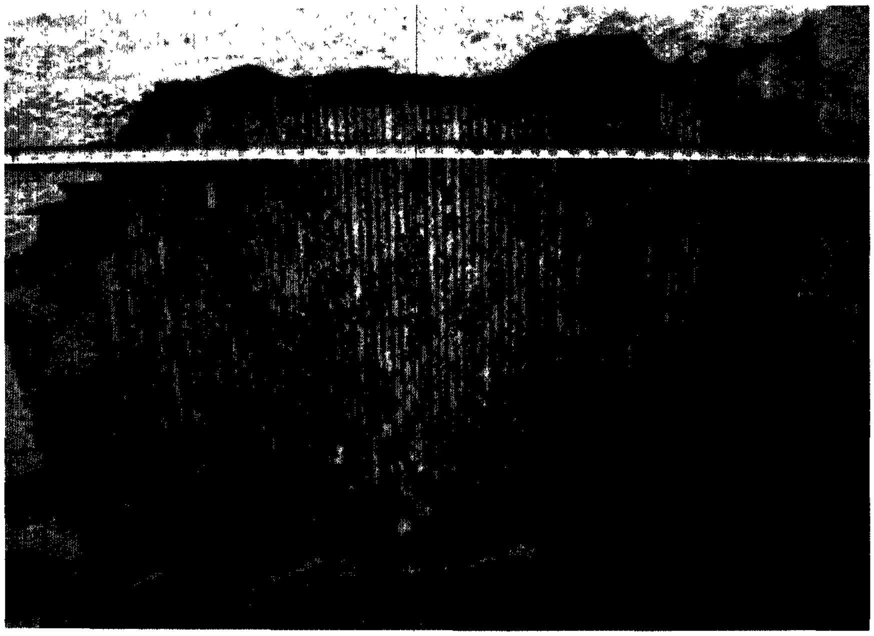


Photo 35

120 in. diameter Pipe #598, southwest side. Close-up of photo 34.

Photo 36

120 in. diameter Pipe #598, southwest side. Crack in the core.

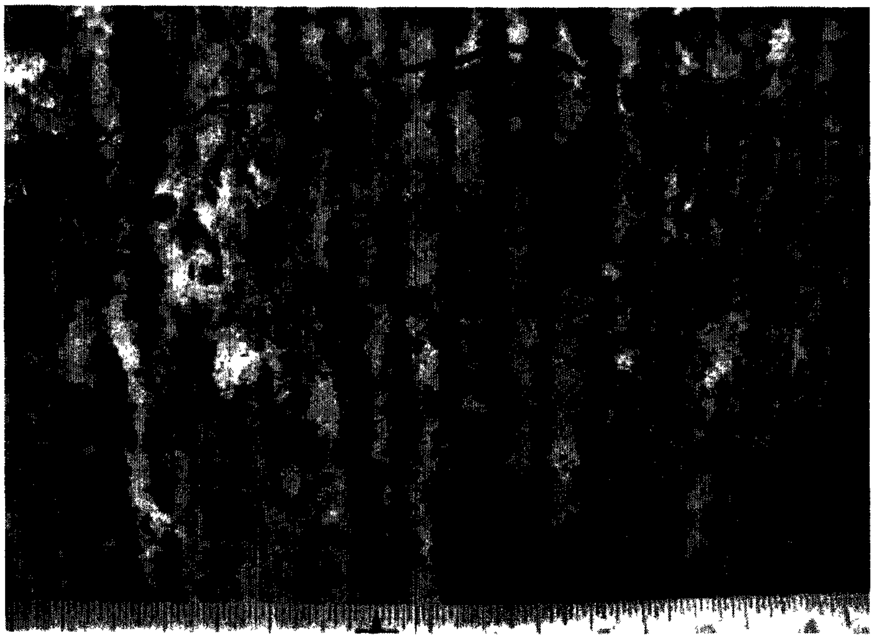


Photo 37

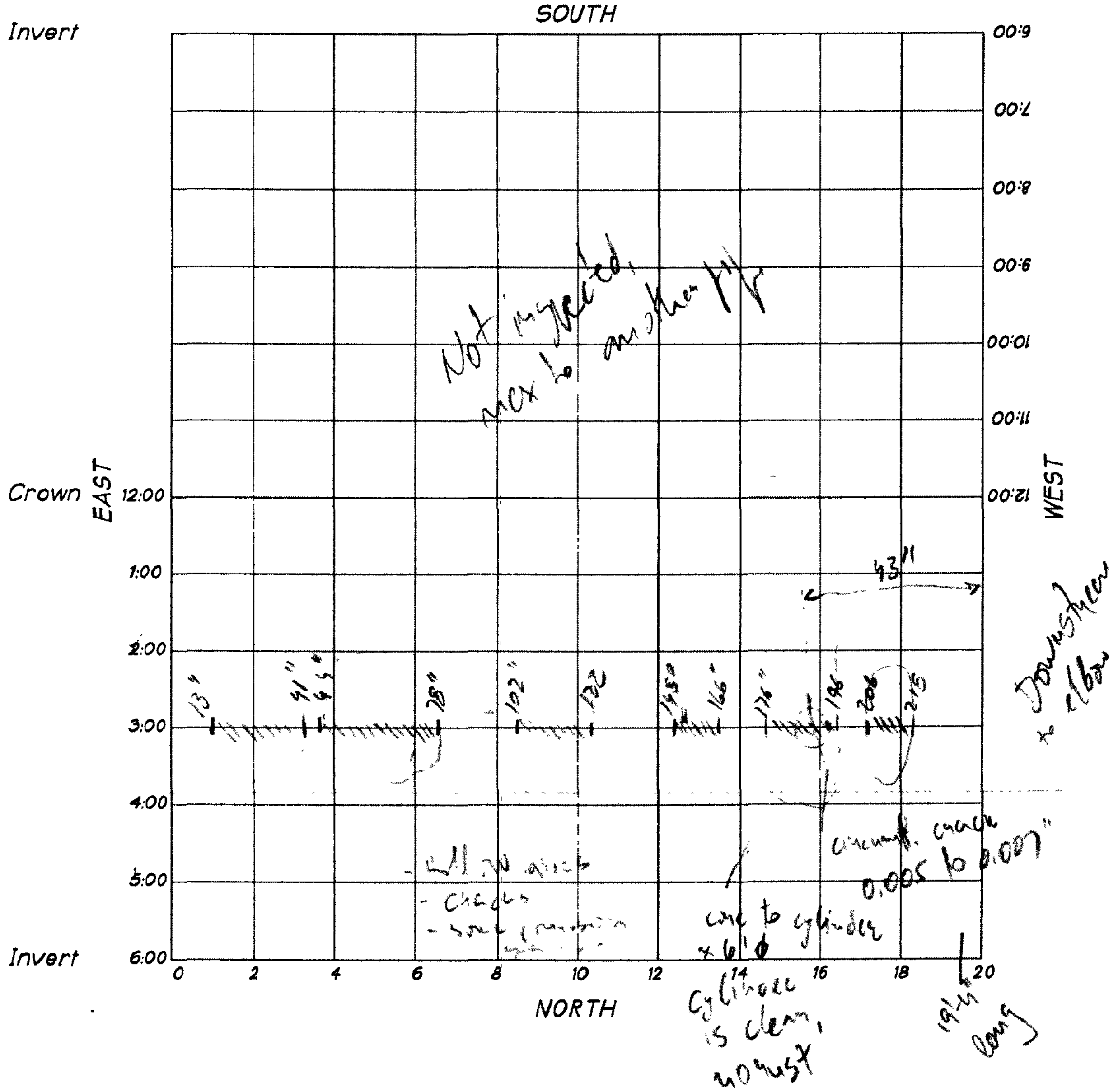
120 in. diameter Pipe #598, southwest side. Crack in the core.

Photo 38

120 in. diameter Pipe #598, southwest side. Crack in the core up to about 0.060 in. wide.

InterMountain Power Service Corporation, Delta, Utah - Field Inspection Report for 84 in. Pipes - November 2003

Pipe No.	Station No.	Break Loc. From East Jnt (ft-in)			Number of Breaks	Length of Breaks Area (in)	Pw+Pt (psi)	Cover (ft)	Pipe Design
		Center	Start	End					
427									



Hollow Sour
Coating cr
Core Cr
Damage N
PS Loss
Damage AV
PS Loss

IP12_003811

InterMountain Power Service Corporation, Delta, Utah - Field Inspection Report for 84 in. Pipes - November 2003

Pipe No.	Station No.	Break Loc. From East Jnt (ft-in)			Number of Breaks	Length of Breaks Area (in)	Pw+Pt (psi)	Cover (ft)	Pipe Design
		Center	Start	End					
476									

UNIT 2